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Ascent Particle Filter Molecular Conductance Study

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Keith R. Olson and Kelsey A. Folgner
Space Materials Laboratory
Physical Sciences Laboratories

Randy M. Villahermosa
Advanced Programs
Missile Defense Space Systems

Prepared for:

Space and Missile Systems Center
Air Force Space Command
483 N. Aviation Blvd.
El Segundo, CA 90245-2808

Authorized by: Engineering and Technology Group

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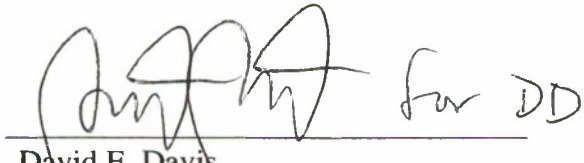
This technical report has been reviewed and is approved for publication. Publication of this report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.



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14. ABSTRACT

Ascent particle filters on enclosures containing space hardware, such as electronics boxes, regulate venting of these enclosures during launch and ascent. While allowing venting to occur, these filters prevent the transport of particles into and out of the enclosures. Particle filters are primarily chracterized with respect to the flow of gas through the filter; the conductance of outgassed molecules is not quantified. This report documents a series of tests performed at The Aerospace Corporation's Space Materials Laboratory to measure the conductance of outgassed molecular contamination from a model contaminant across a typical particle filter as a function of outgassing arrival rate. The results herein show that a typical ascent particle filter significantly limits the conductance of molecular contamination.

15. SUBJECT TERMS

Particle filter, Venting, Conductance, Molecular contamination, Outgas

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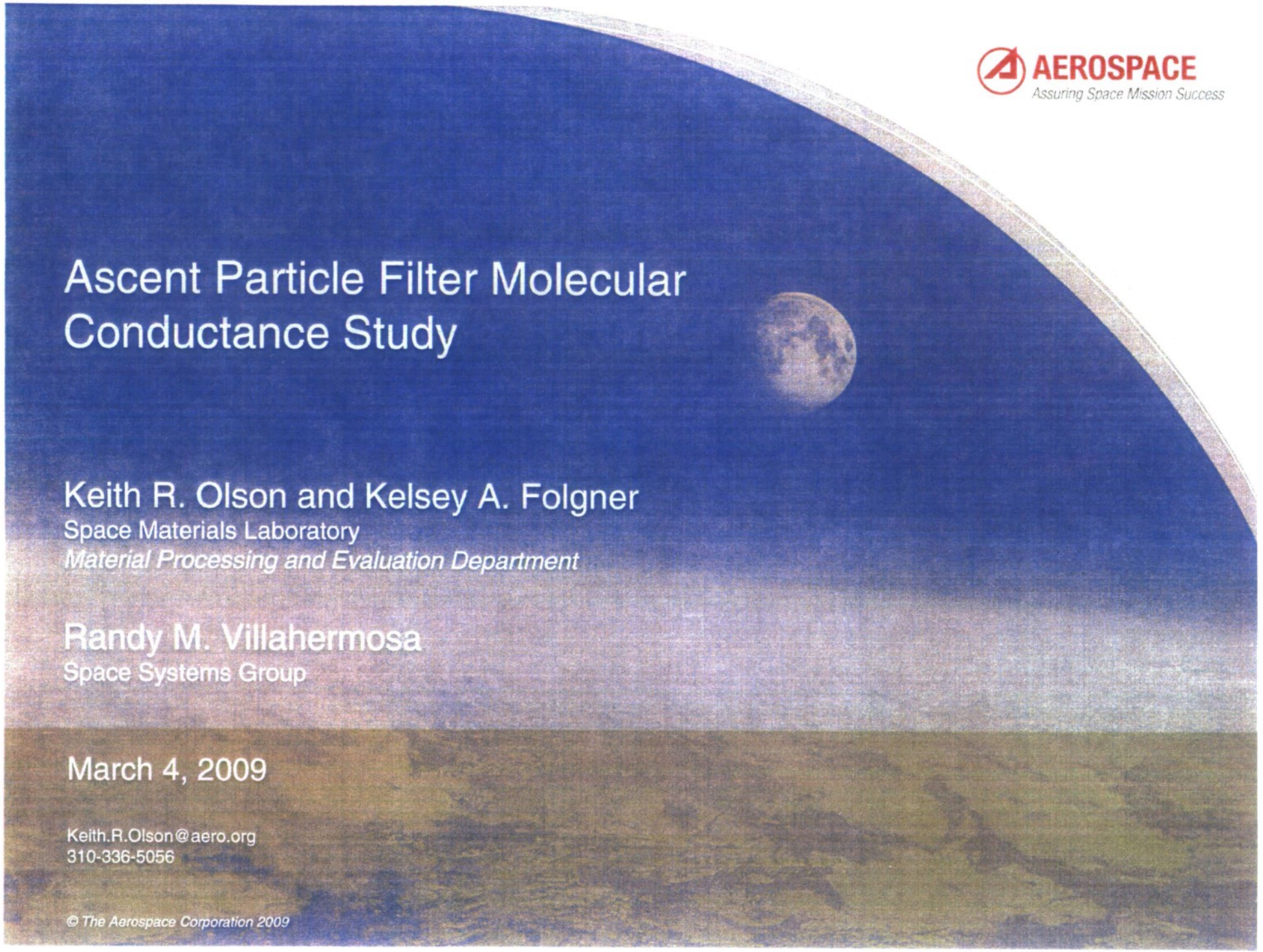

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Ascent Particle Filter Molecular Conductance Study

Keith R. Olson and Kelsey A. Folgner
Space Materials Laboratory
Material Processing and Evaluation Department

Randy M. Villahermosa
Space Systems Group

March 4, 2009

Keith.R.Olson@aero.org
310-336-5056

Ascent Particle Filter Molecular Conductance Study

Introduction

- Particle filters on enclosures containing space hardware (electronics boxes, etc.) provide venting during launch and ascent
- Filters are typically sized in the 5 to 10 µm effective filtration range
  - *Prevent the ingestion of particles into the assembly*
  - *Prevent the release of particles from the interior of the enclosure*
- Filters are most often characterized with respect to the flow of gas through the filter
  - *Conductance of outgassed molecules is not quantified*

Question to Answer: To what extent does a typical ascent particle filter limit the conductance of molecular contamination?

Ascent Particle Filter Molecular Conductance Study

Experiment Design

- Molecular conductance through a filter can be thought of in two ways:
  - ***Effective Aperture Size:*** *Size of the obstruction-free aperture that will pass molecules at the same rate as the filter*
  - ***Mass Throughput:*** *Percentage of mass per unit time that the filter can pass relative to an unobstructed target*
- Molecular conductance is considered to be a function of:
  - *Filter parameters (design, effective filtration size, material, etc.)*
  - *Macro dimensions of the filter (length, width, thickness)*
  - *Temperature of the filter*
  - *Rate of outgassing arrival*
- **Objective:** Measure the molecular conductance* across a typical filter as a function of outgassing arrival rate for a model contaminant (Dioctyl Phthalate)

* Molecular conductance measured for a Clausing beam profile, not for an omnidirectional pressure distribution. These experiments can be thought of as measuring the mass throughput attenuation of the ascent particle filter.

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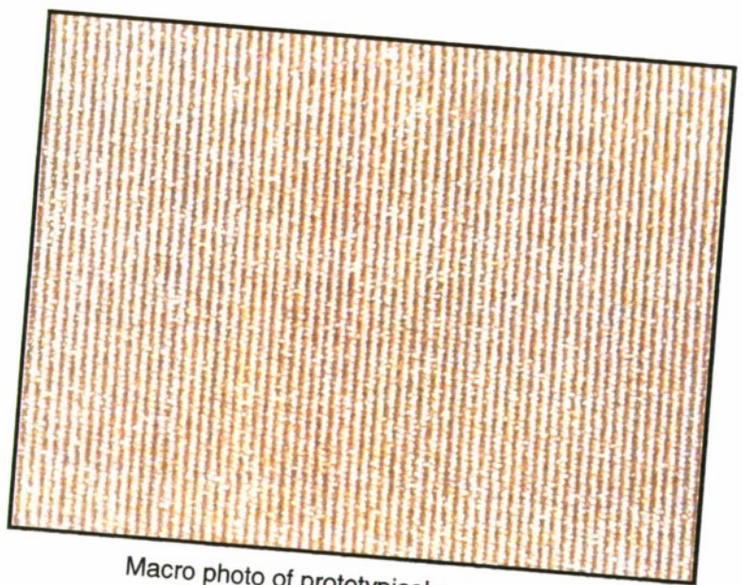
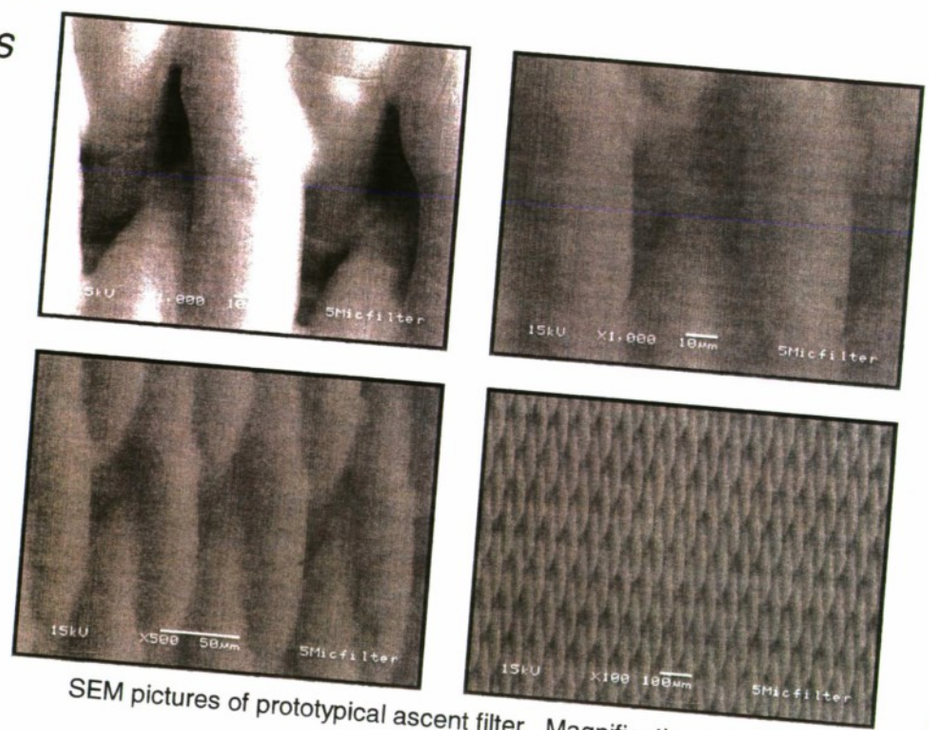
Prototypical Ascent Filter

- Rigimesh 5 µm Filter from Pall Aeropower Corporation
  - *Wire Thickness: 0.0014 inches*
  - *Filter Thickness: 0.006 inches*



Macro photo of prototypical ascent filter.



SEM pictures of prototypical ascent filter. Magnification specified.

Prototypical sintered stainless steel wire mesh filter

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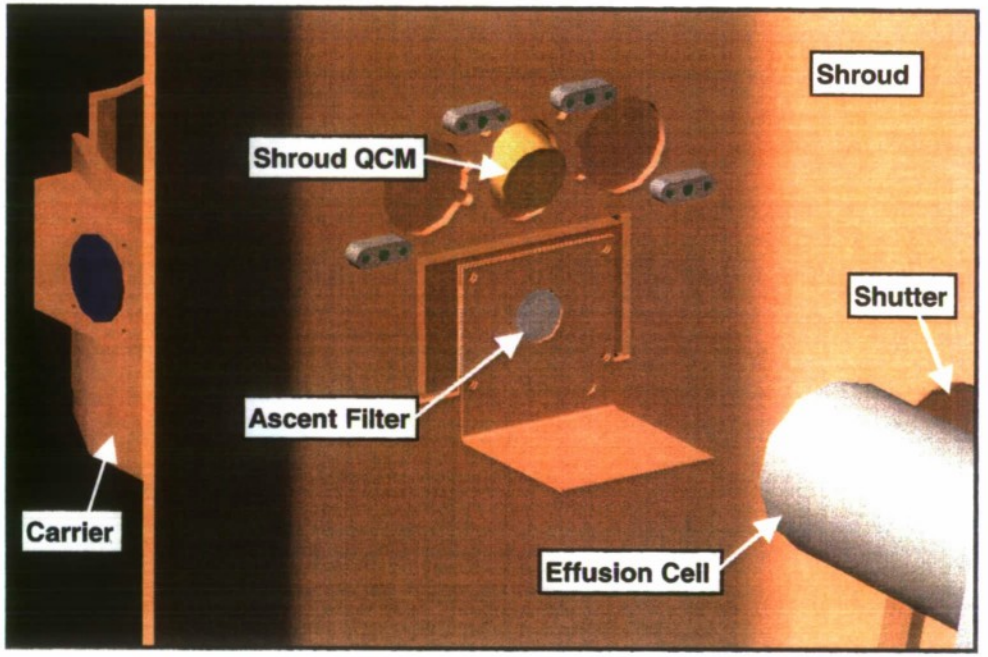
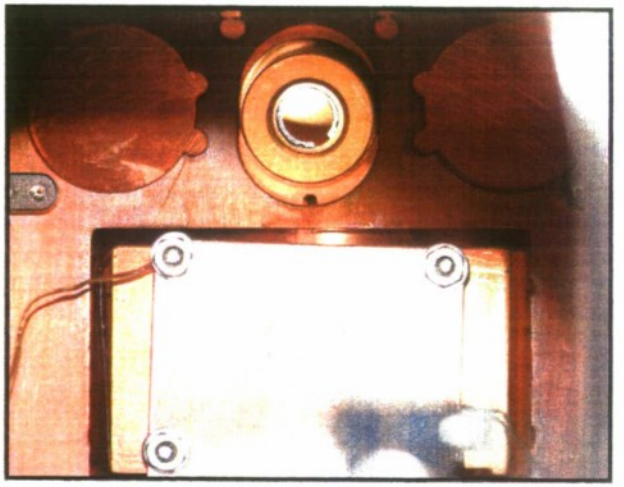
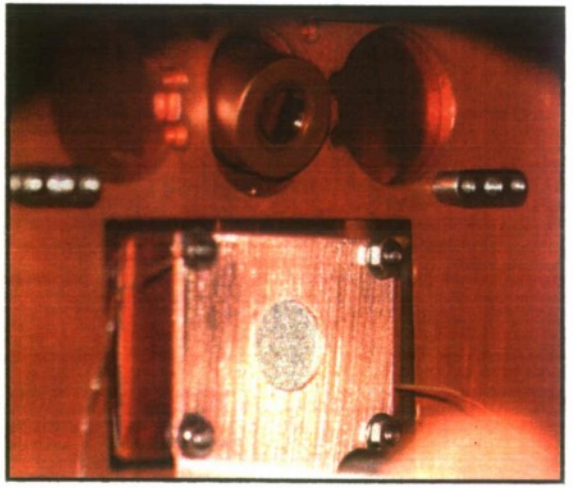
Chamber Configuration







The Carrier QCM, which is mounted on the Carrier, is identical to the Shroud QCM. For this study, it was located directly behind the Ascent Filter, with a gap of approximately 0.2 inches. Both QCMs were held at -75°C to collect all impinging flux, but not condense water.

Ascent particle filter mounted in chamber for testing

Ascent Particle Filter Molecular Conductance Study

Experiment Overview

- QCM Calibration
  - *Calibrate the unobstructed Carrier QCM to the Shroud QCM to understand mass accumulation rate differences*
- Install the filter approximately 0.2 in directly in front of the Carrier QCM
- 21 °C Single Filter Tests
  - *Measure mass accumulation on the Carrier QCM & Shroud QCM with the single filter held at 21 °C (+2 °C, -1 °C) for each molecular flux of interest*
- 5 °C Single Filter Tests
  - *Measure mass accumulation on the Carrier QCM & Shroud QCM with the single filter held at 5 °C (+2 °C, -1 °C) for each molecular flux of interest*

Filter testing performed at two filter temperatures and multiple molecular flux levels

Ascent Particle Filter Molecular Conductance Study

Single Filter Test Accumulation Rate* Summary

* All Rates in Angstroms per hour (Å/hr)		4/21/2008 QCM Calibration		4/29/2008 21°C Single Filter		5/14/2008 21°C Single Filter		5/28/2008 21°C Single Filter		5/28/2008 5°C Single Filter		5/29/2008 5°C Single Filter	
Background†	Carrier QCM	0.038 ‡		0.488		0.709		0.469		0.452		1.358	
	Shroud QCM	0.115 ‡		0.087		0.445		1.240		0.668		0.704	
Effusion Cell 30°C	Carrier QCM	1.060	75.2% §	0.091	10.2% §	0.212	16.8% §						
	Shroud QCM	1.409		0.894		1.260							
Effusion Cell 50°C	Carrier QCM	10.70	98.1% §	0.370	3.9% §	0.434	4.4% §			0.114	1.2% §	0.291	3.1% §
	Shroud QCM	10.91		9.512		9.874				9.426		9.517	
Effusion Cell 60°C	Carrier QCM							1.155	3.6% §	0.692	2.2% §	0.784	2.5% §
	Shroud QCM							31.65		31.70		31.79	
Effusion Cell 70°C	Carrier QCM	97.32	96.9% §	3.975	4.0% §			2.962	3.0% §	1.922	2.0% §	1.680	1.7% §
	Shroud QCM	100.4		100.3				100.0		97.99		97.95	
Effusion Cell 80°C	Carrier QCM							9.770	3.3% §	3.983	1.4% §	4.163	1.5% §
	Shroud QCM							292.5		283.6		284.2	

† Background rates measured with the effusion cell at 10°C and the shutter closed before all depositions each day (0Å deposited on each QCM)

‡ Measured after calibrations at 30°C, 50°C, and 70°C (Approximately 240Å deposited on each QCM)

§ Carrier QCM Rate as a percentage of the Shroud QCM Rate during the same deposition

Ascent Particle Filter Molecular Conductance Study

Summary

- To what extent does a typical ascent particle filter limit the conductance of molecular contamination?

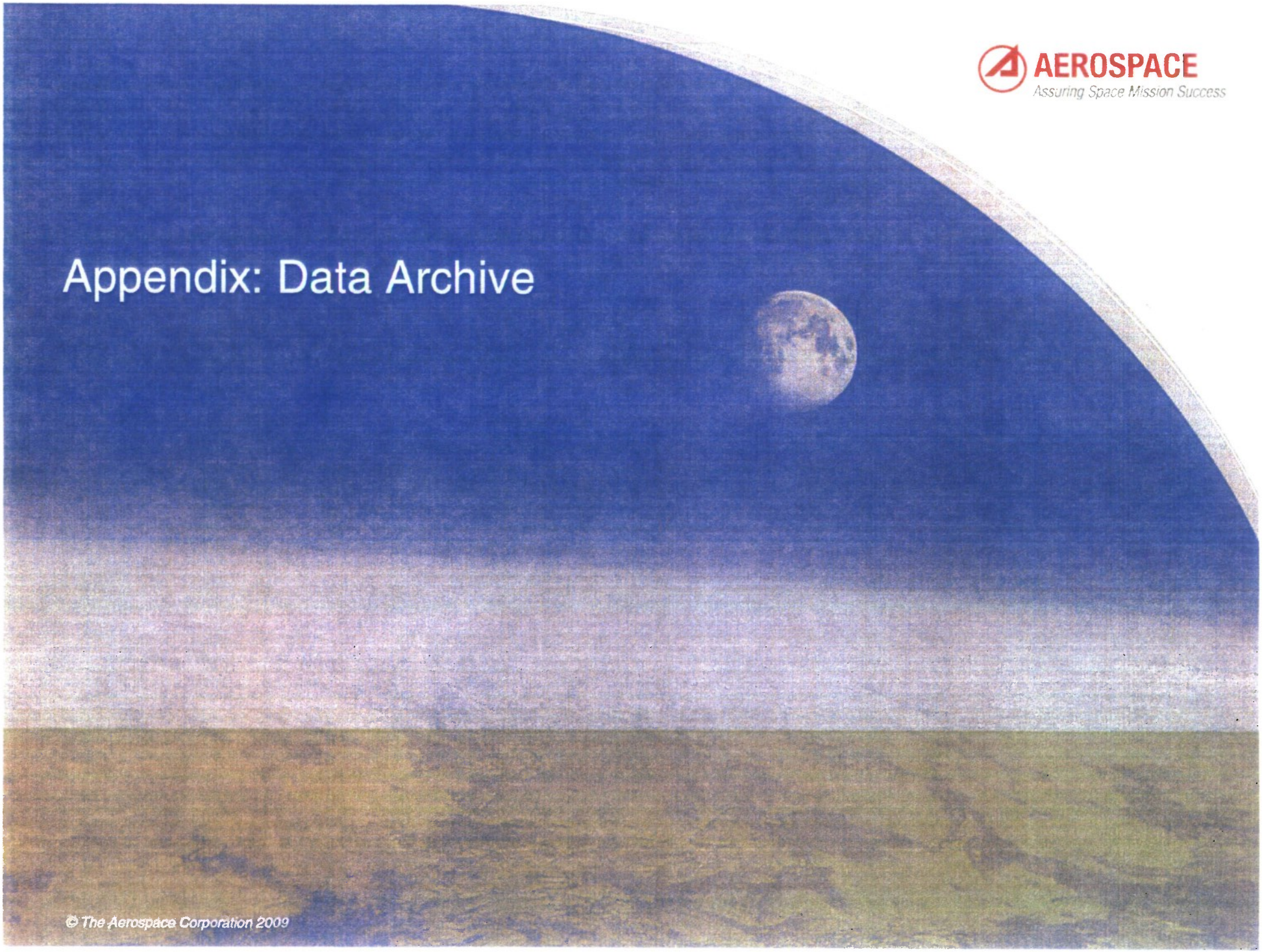
21 °C Single Filter Tests

- The filter reduced the mass accumulation on the Carrier QCM to between 3.0% and 4.4% of the accumulation on the unobstructed Shroud QCM

5 °C Single Filter Tests

- The filter reduced the mass accumulation on the Carrier QCM to between 1.2% and 3.1% of the accumulation on the unobstructed Shroud QCM

Note: Data recorded with the effusion cell at 30°C is difficult to interpret because the deposition rates were very low.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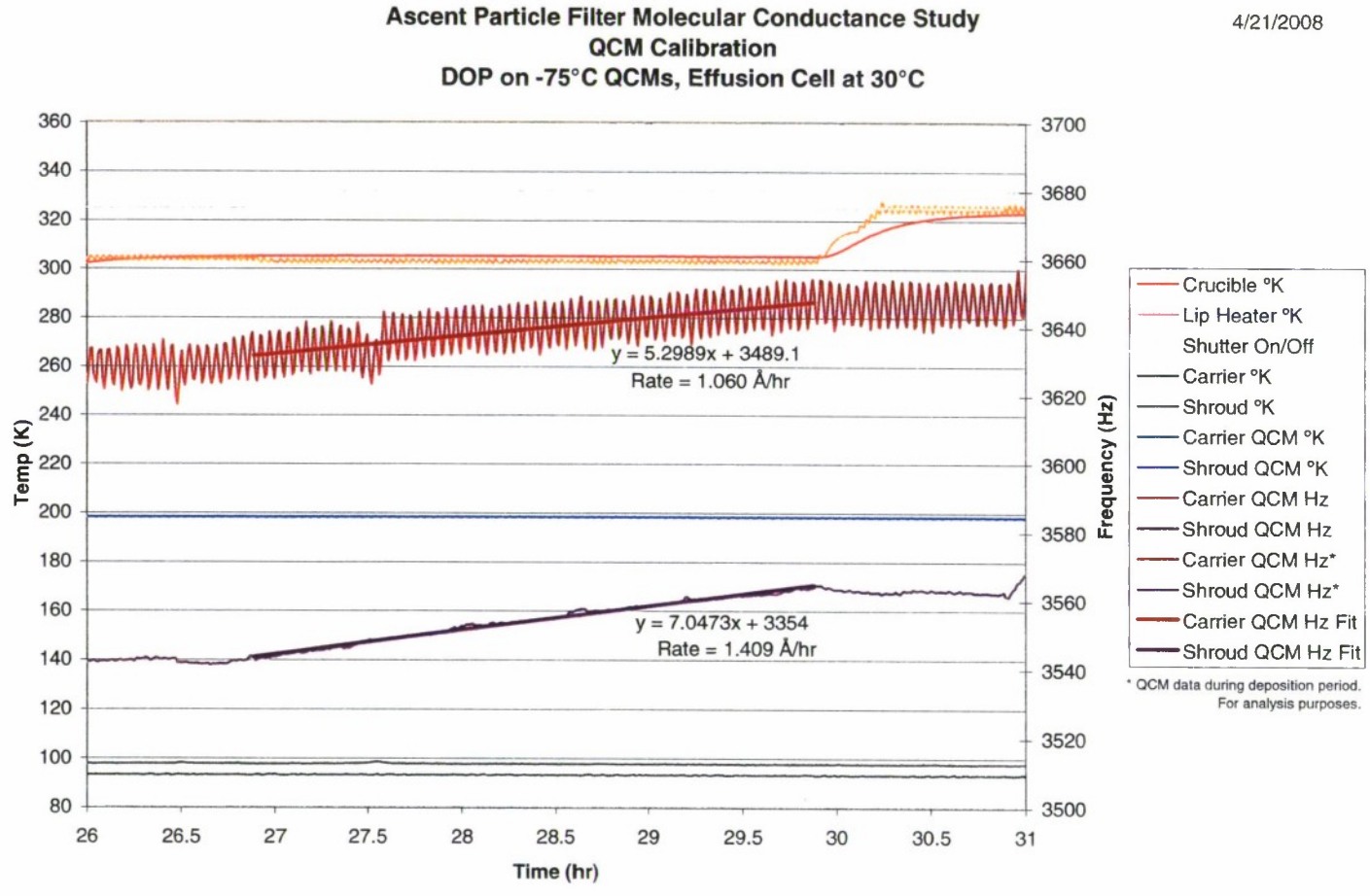

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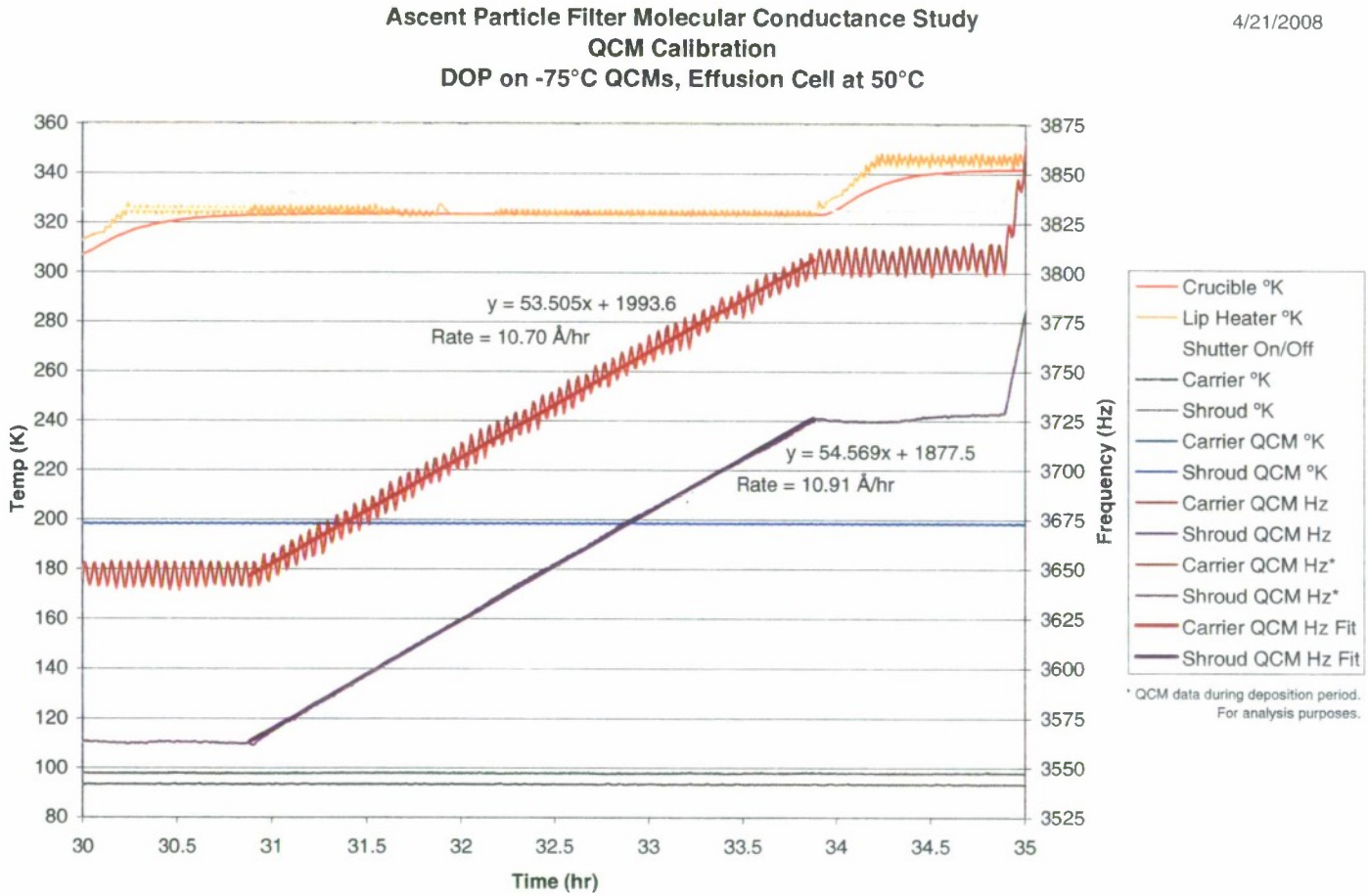

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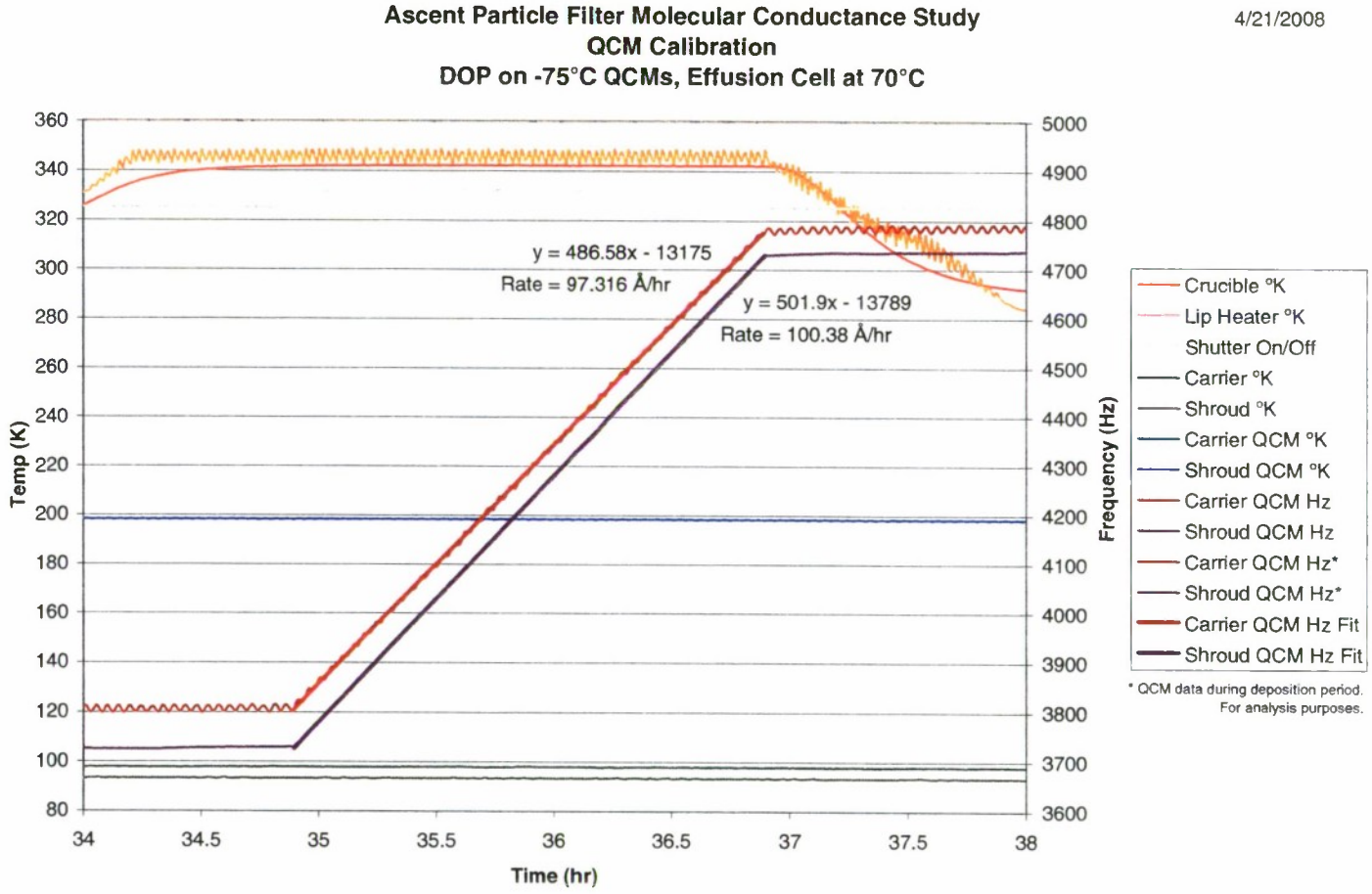

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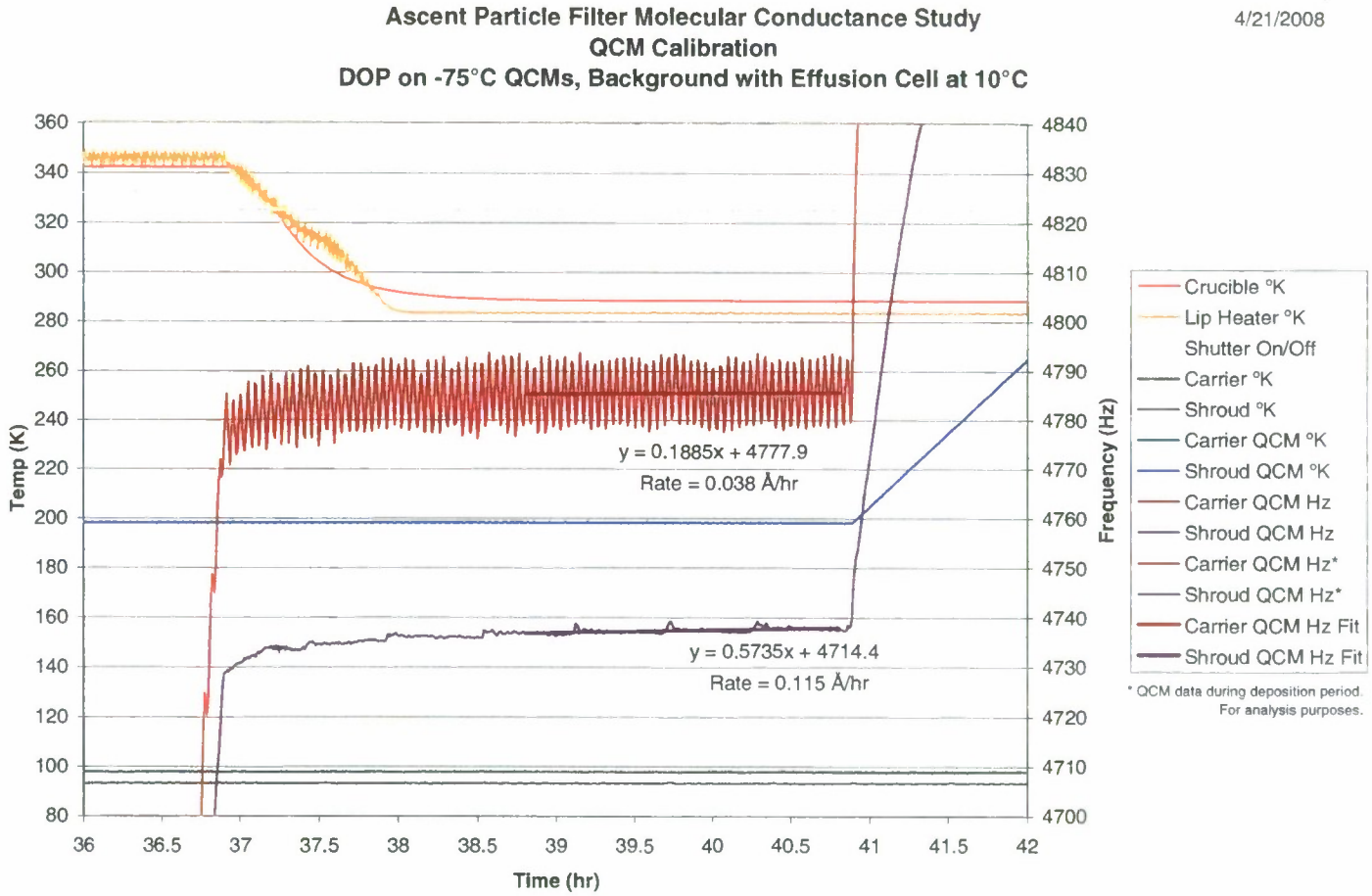

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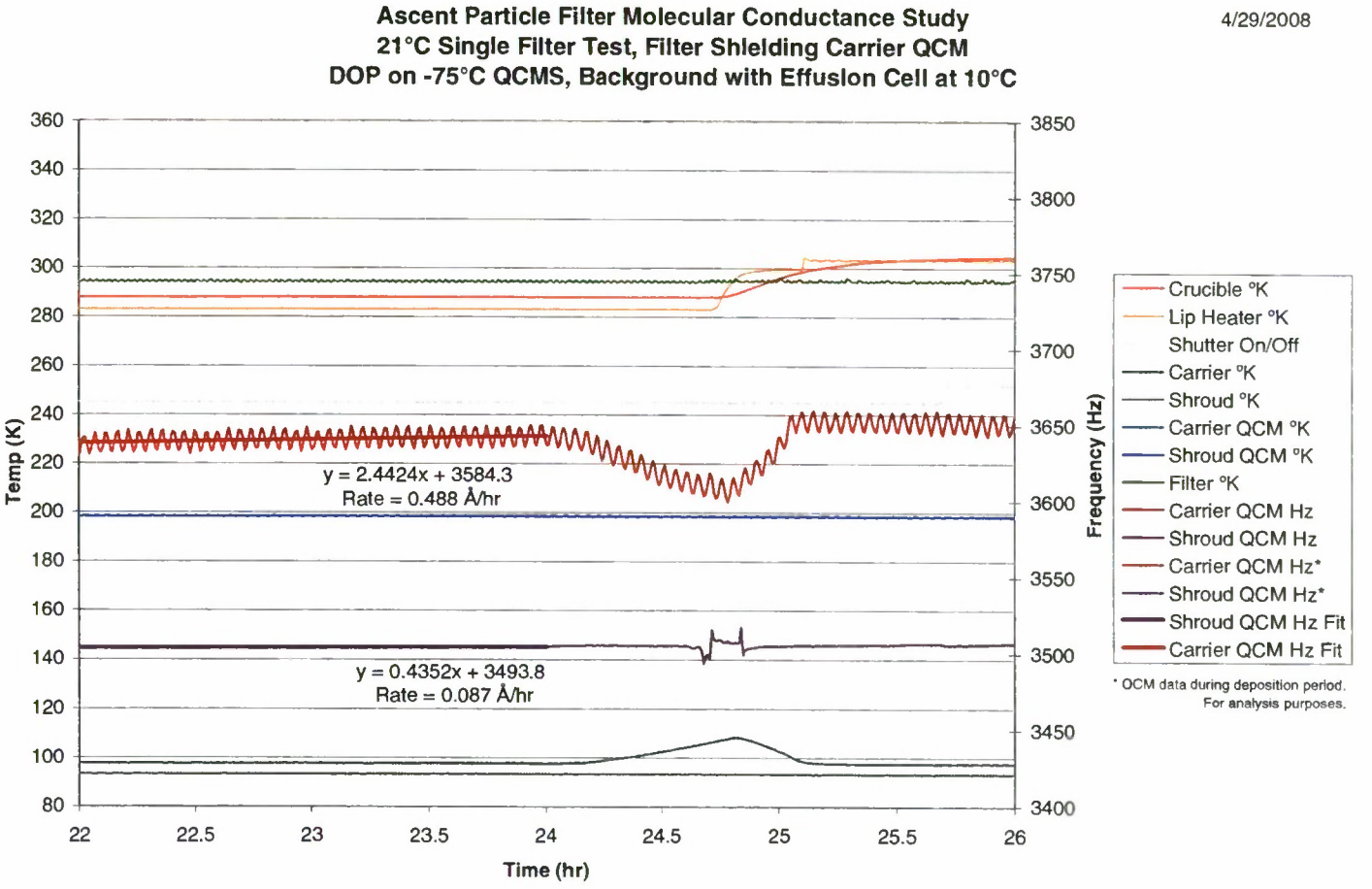

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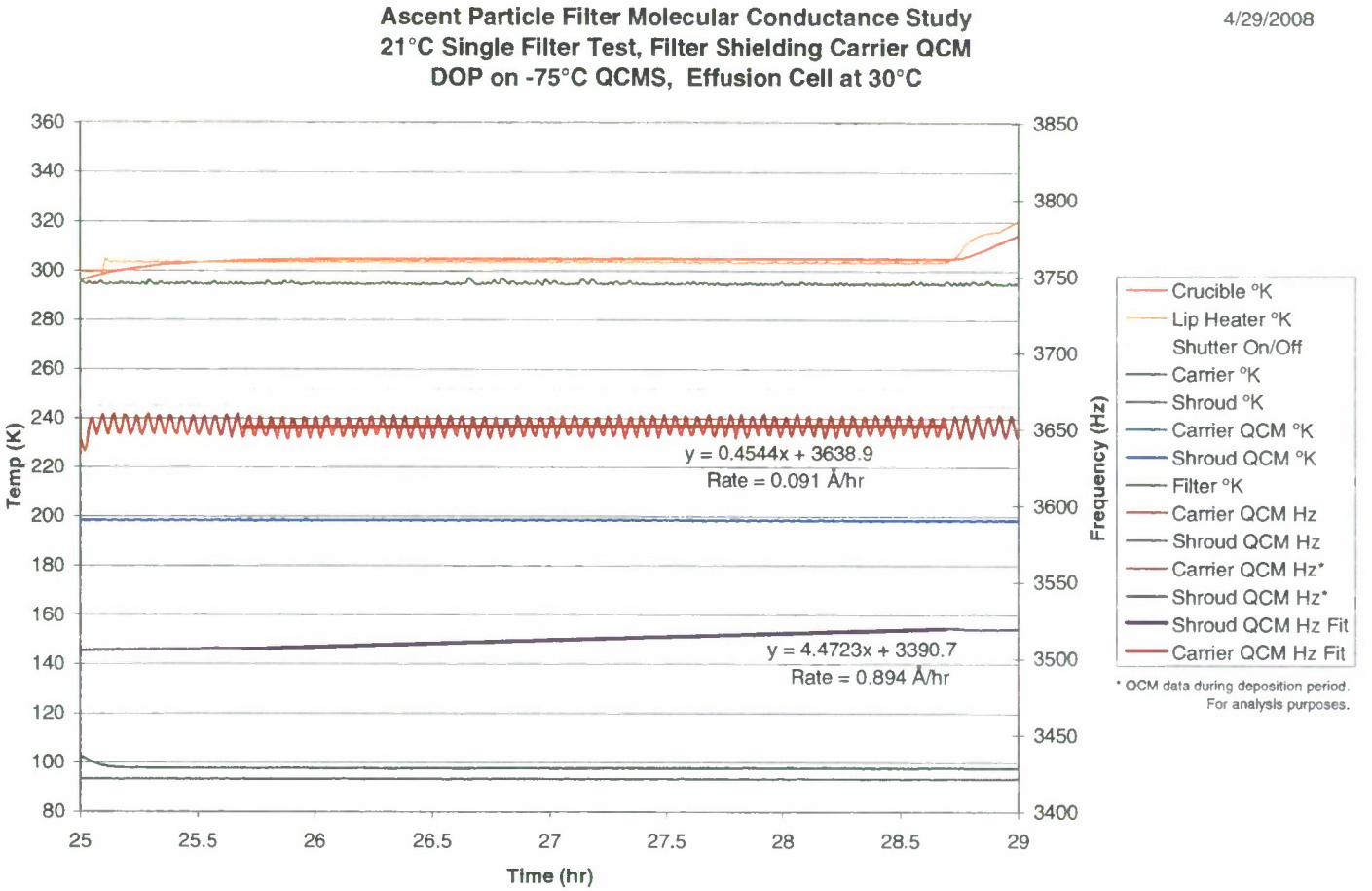

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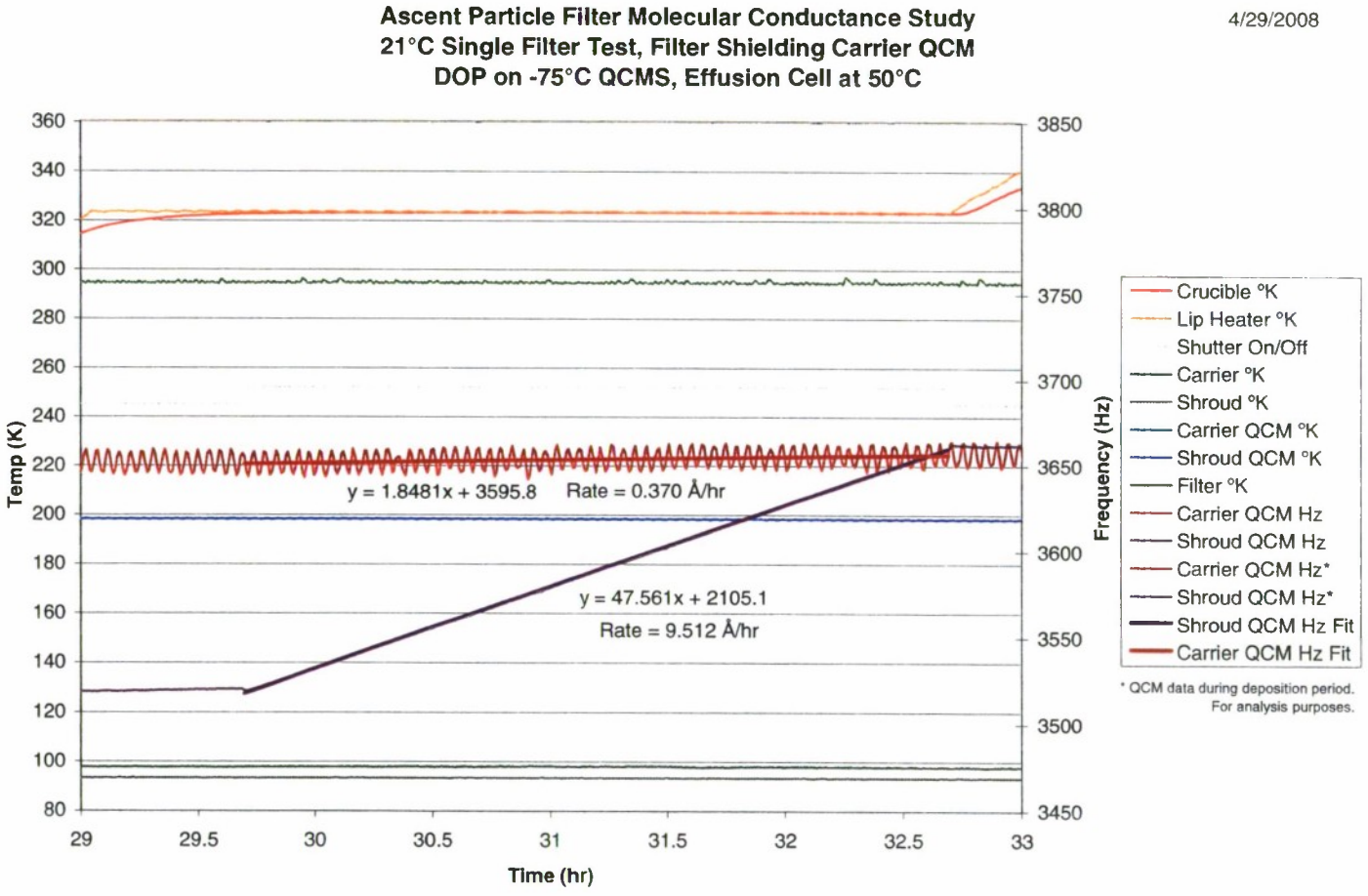

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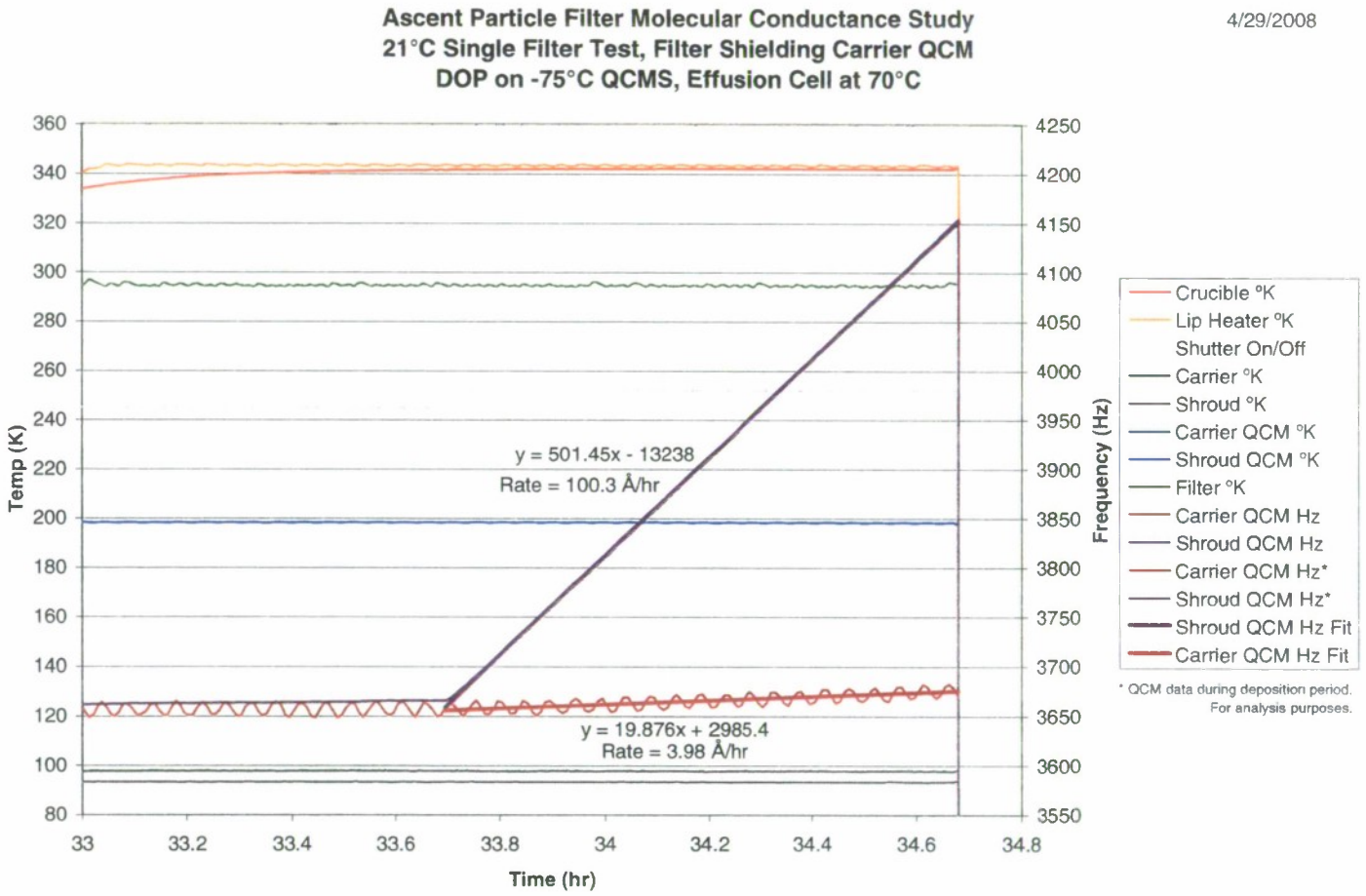

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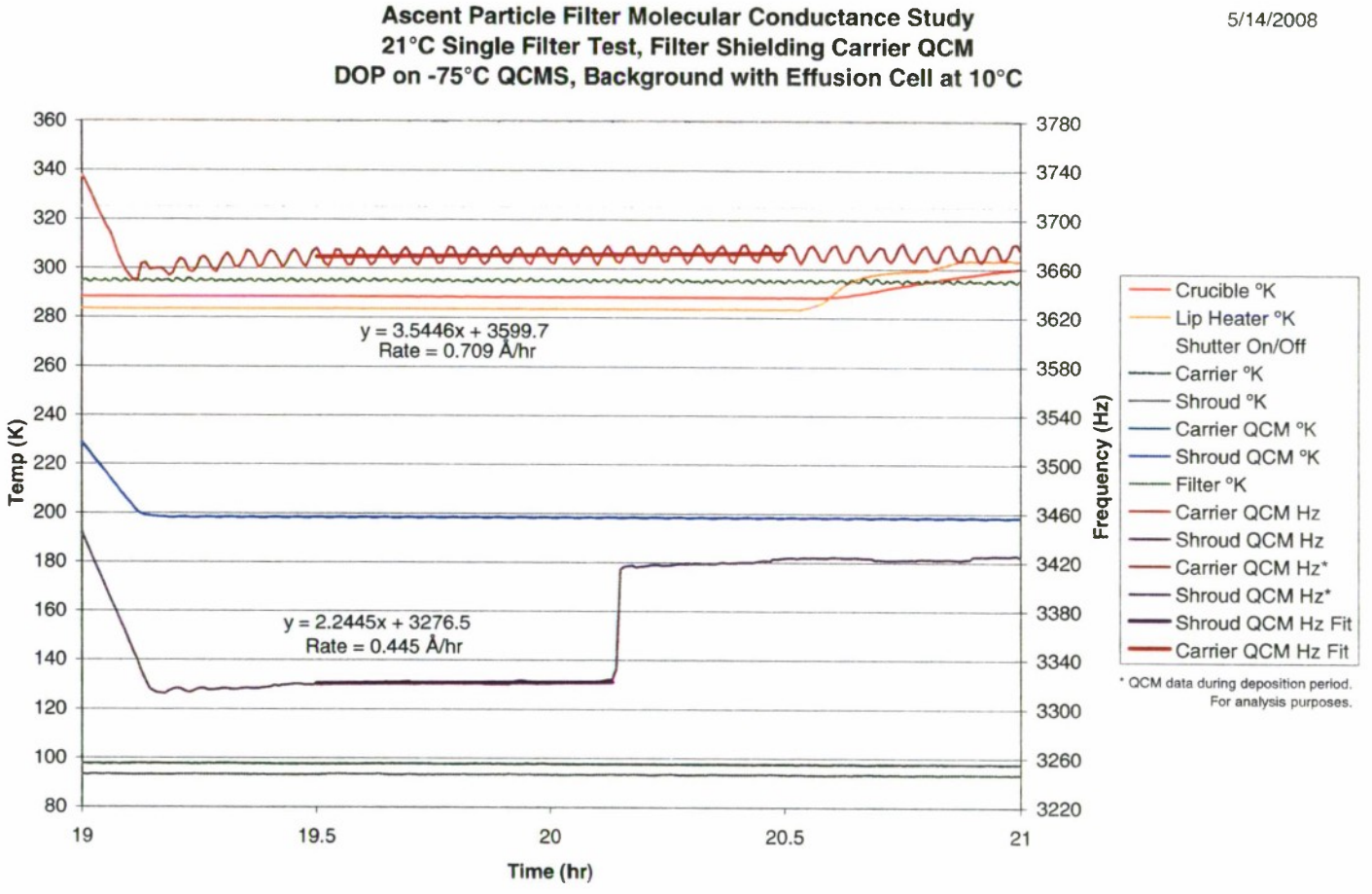

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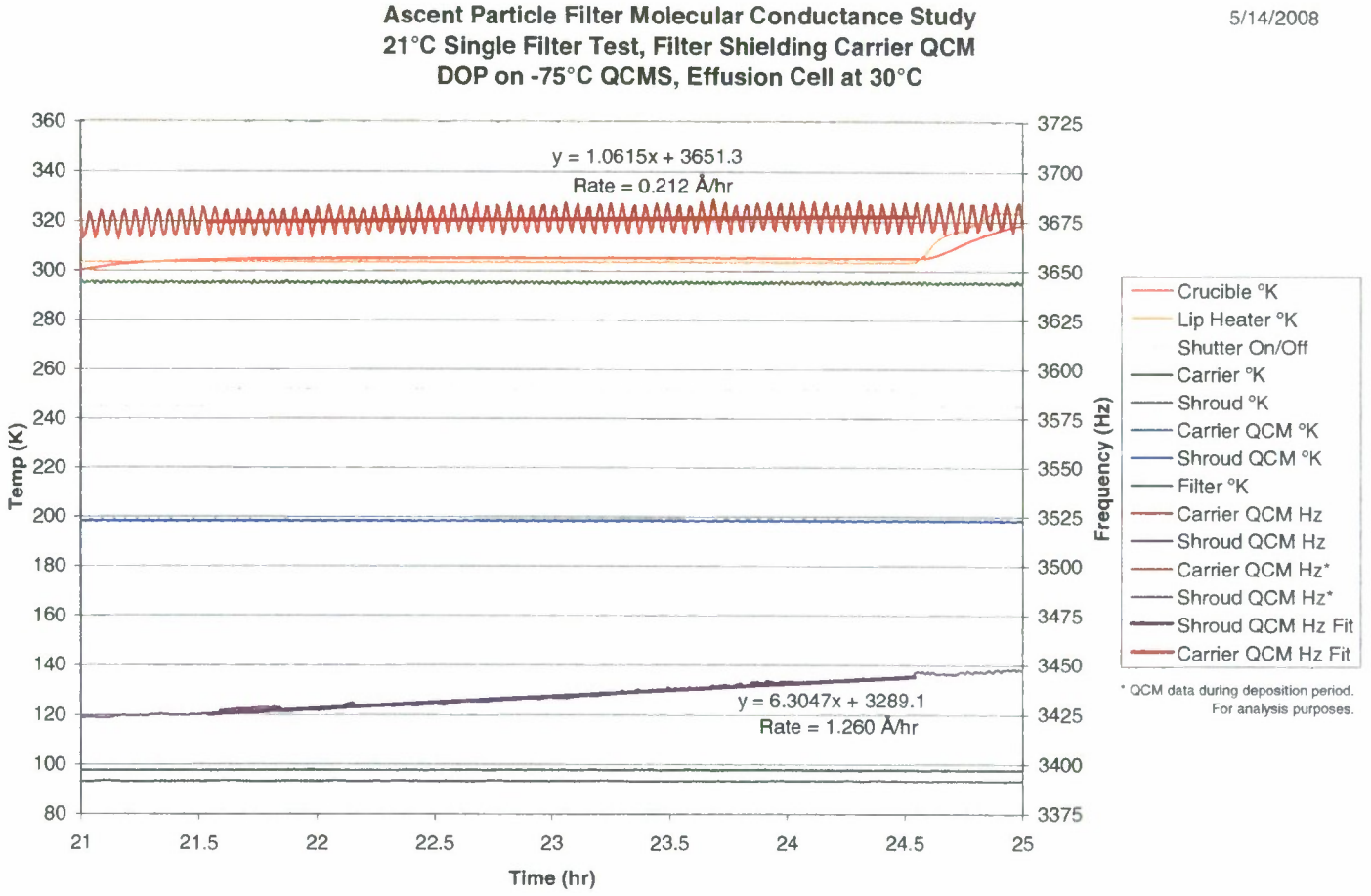

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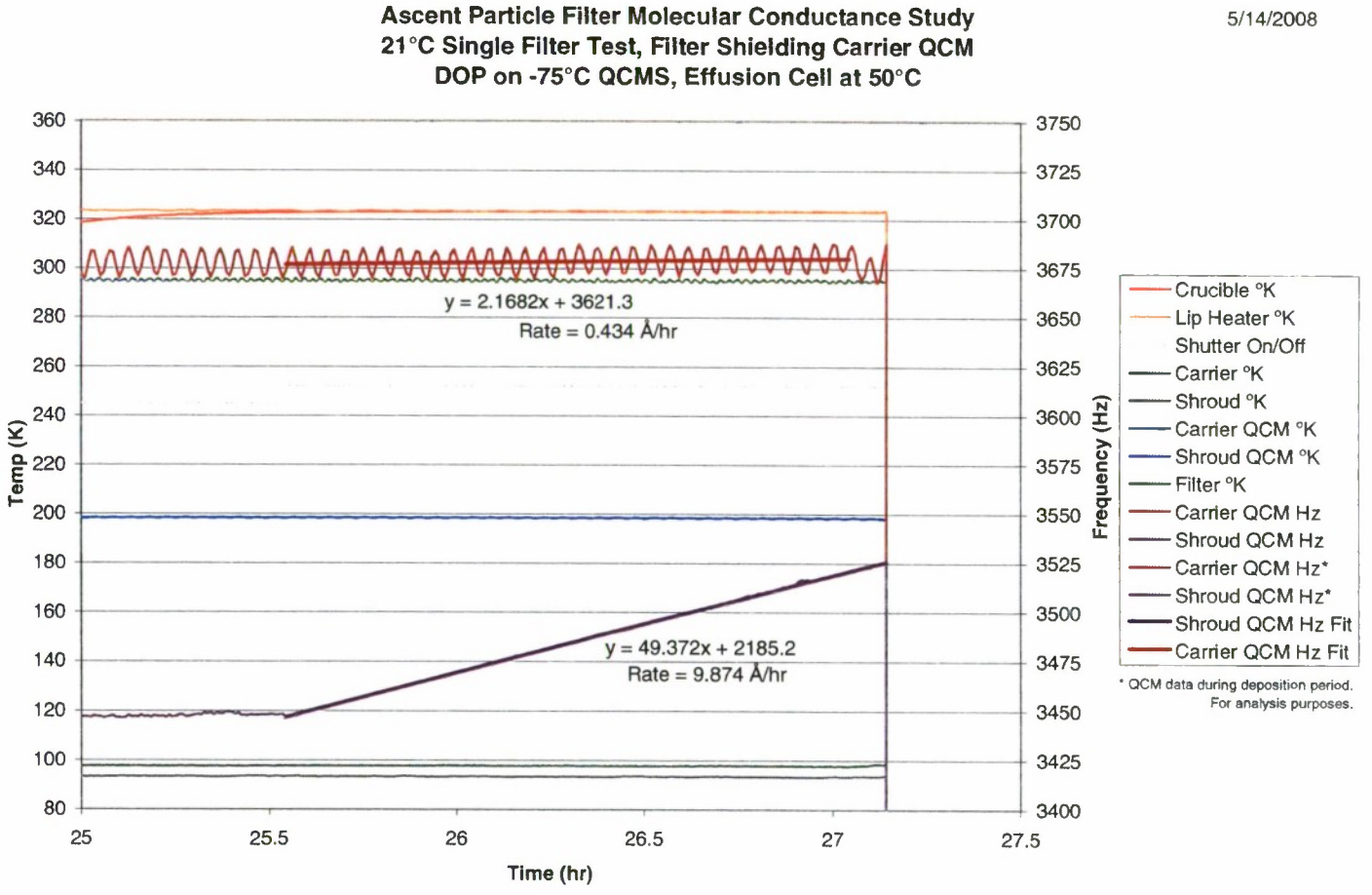

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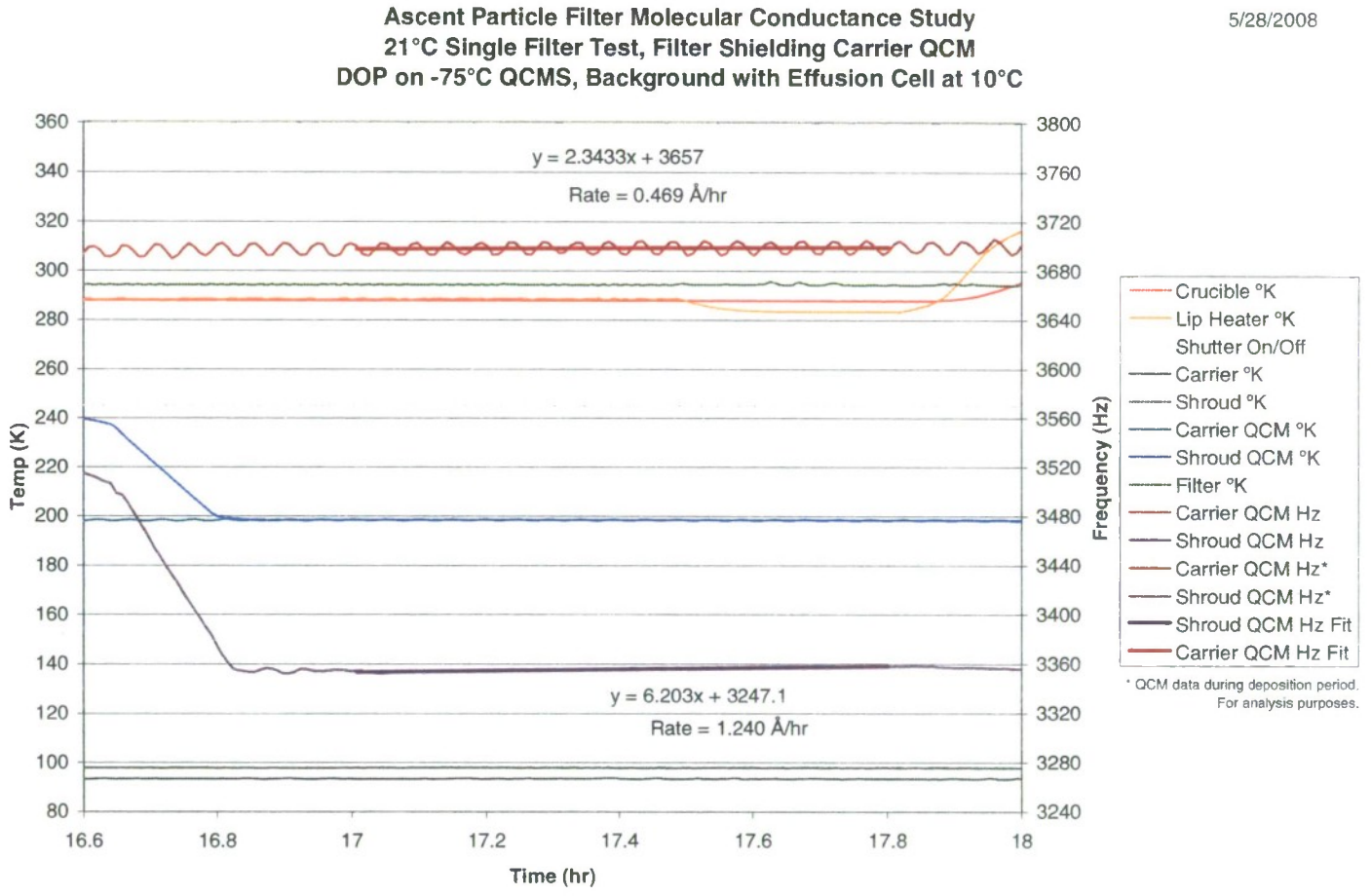

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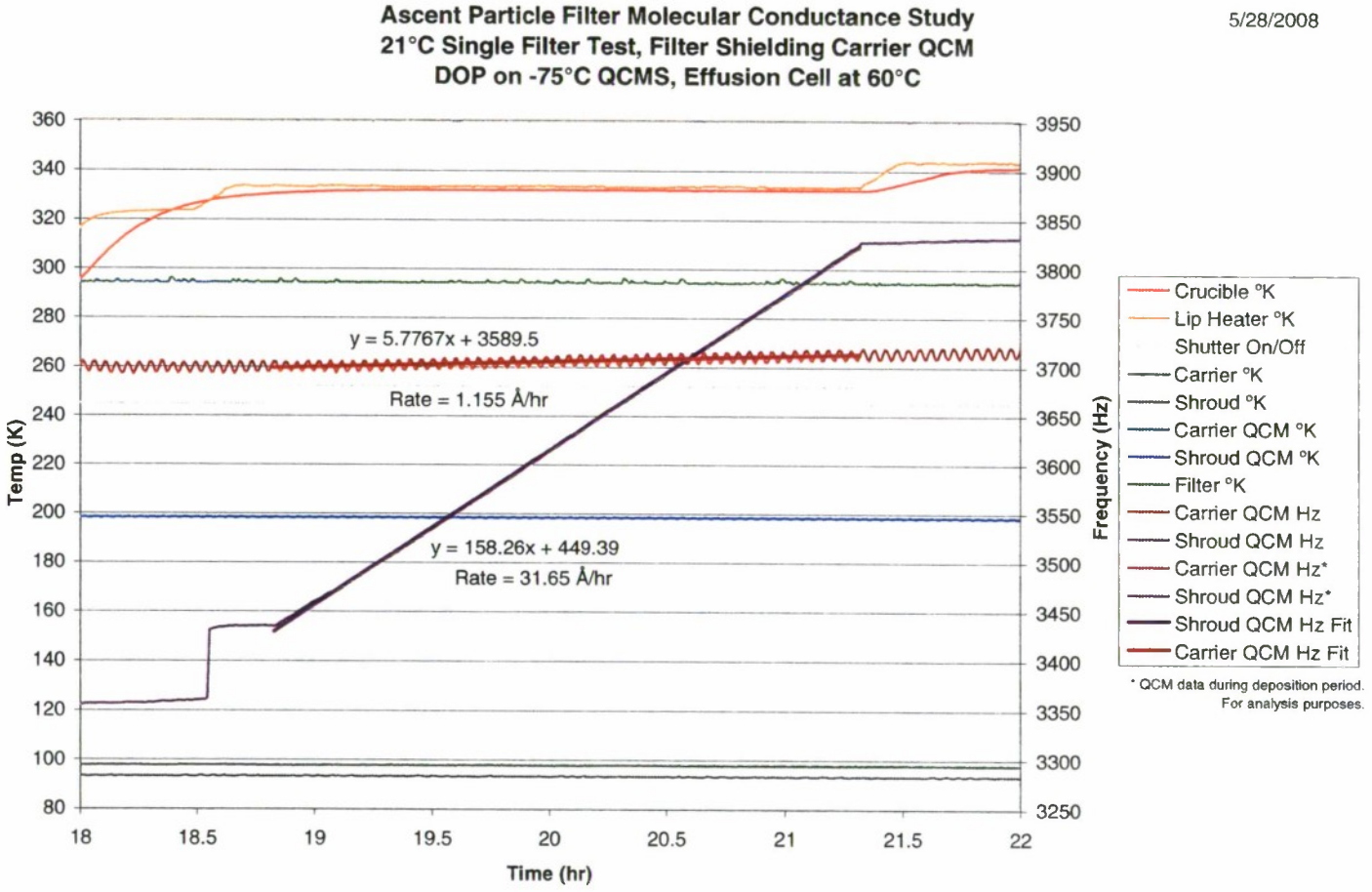

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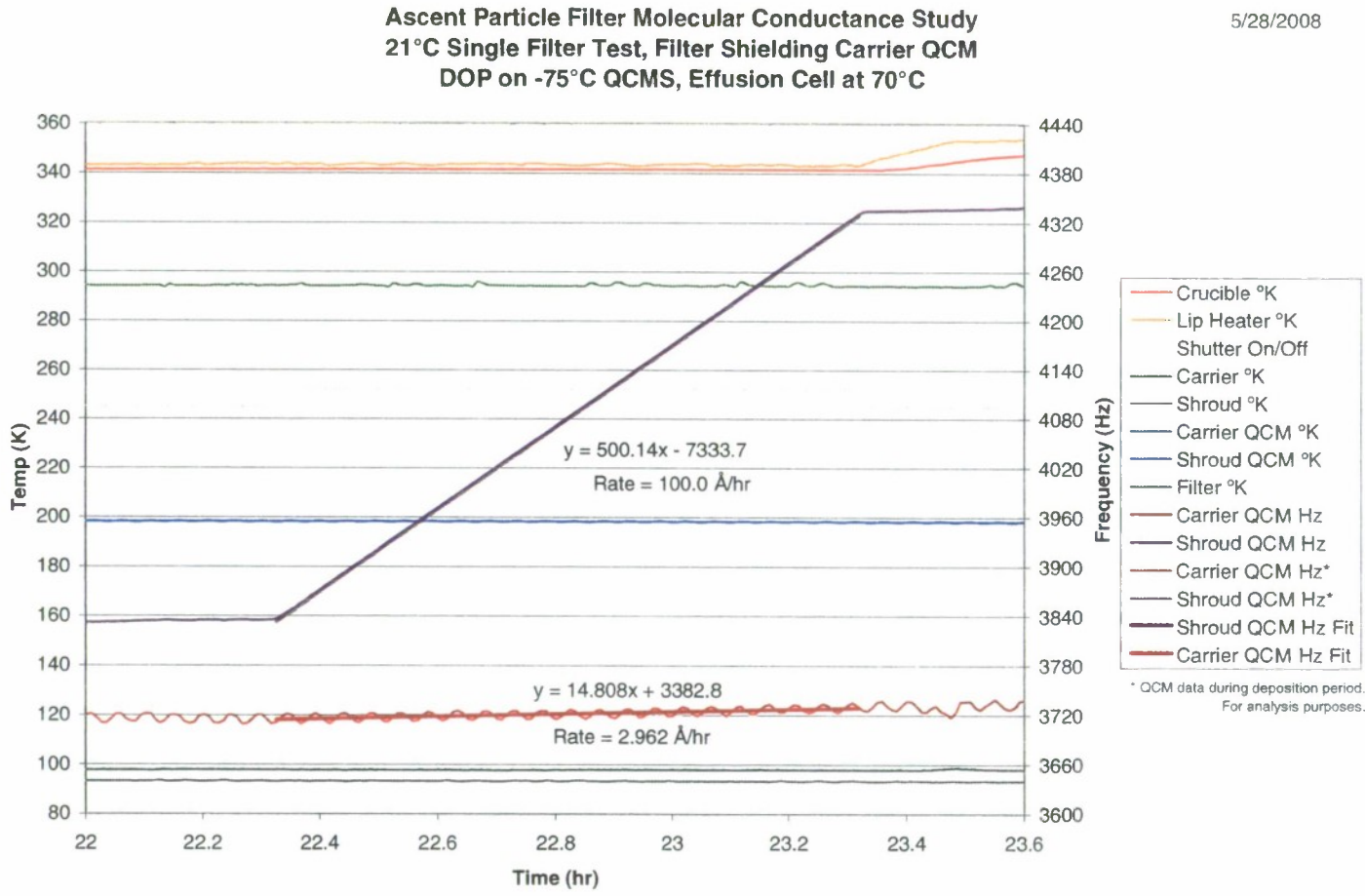

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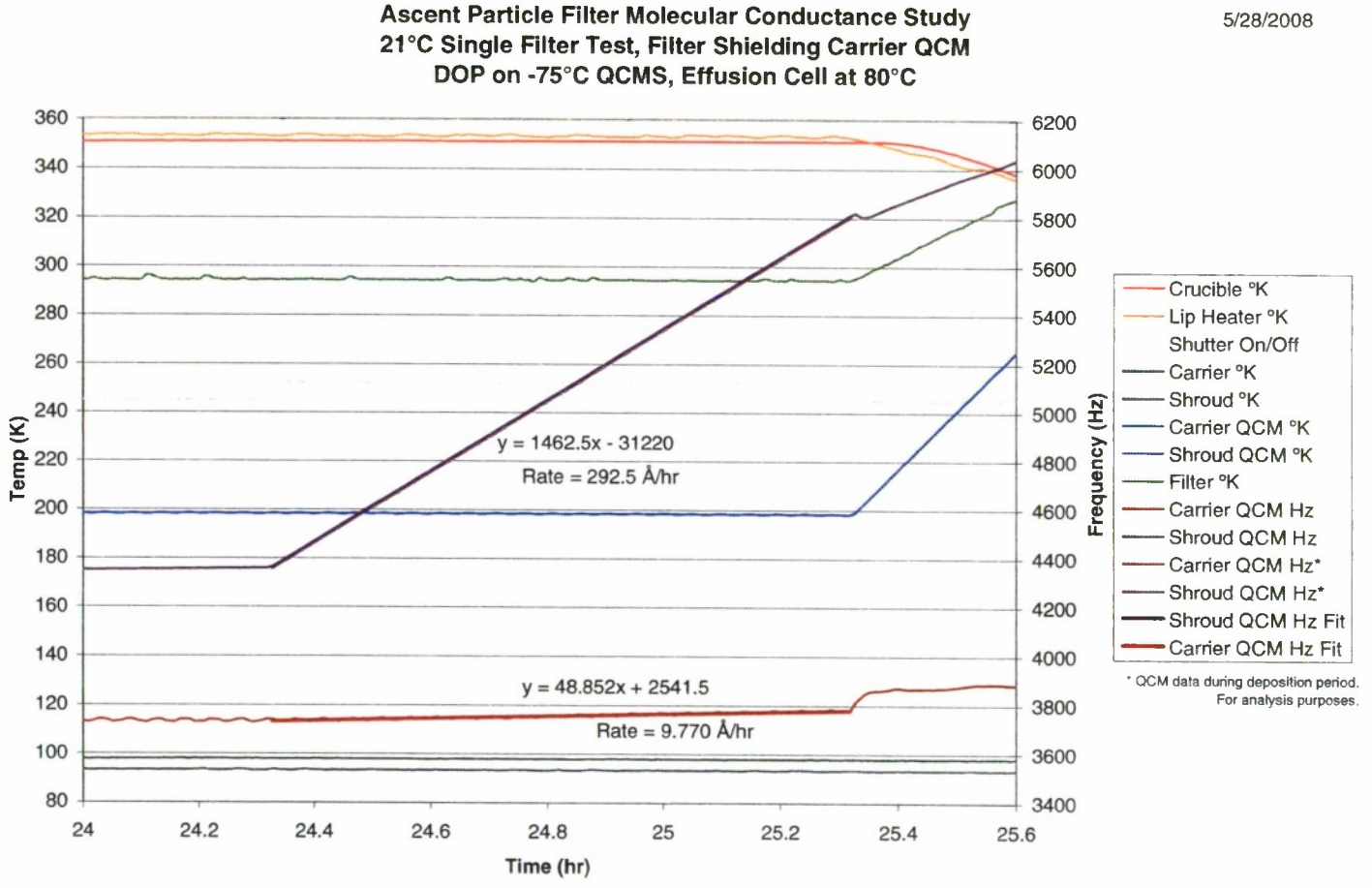

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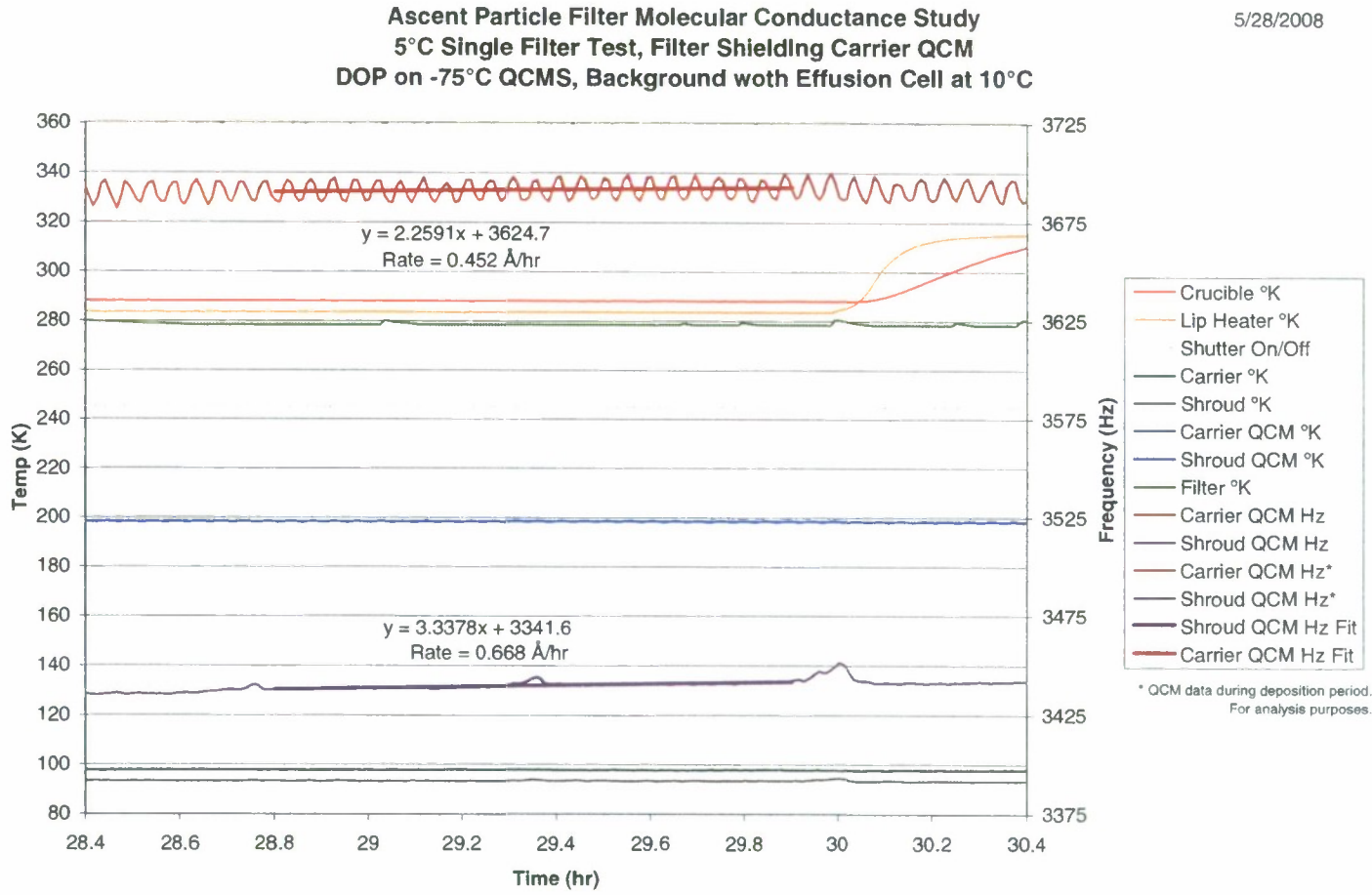

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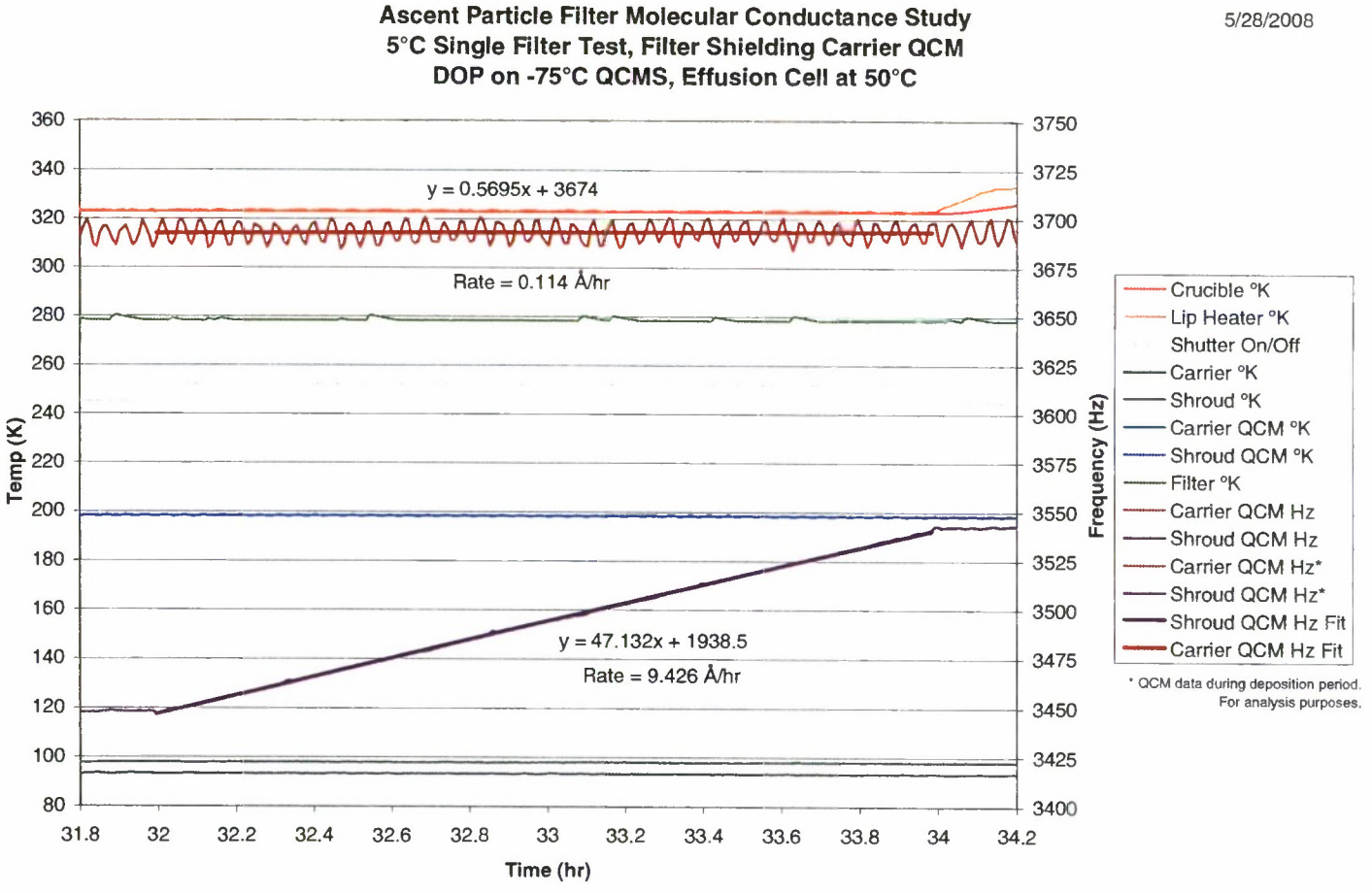

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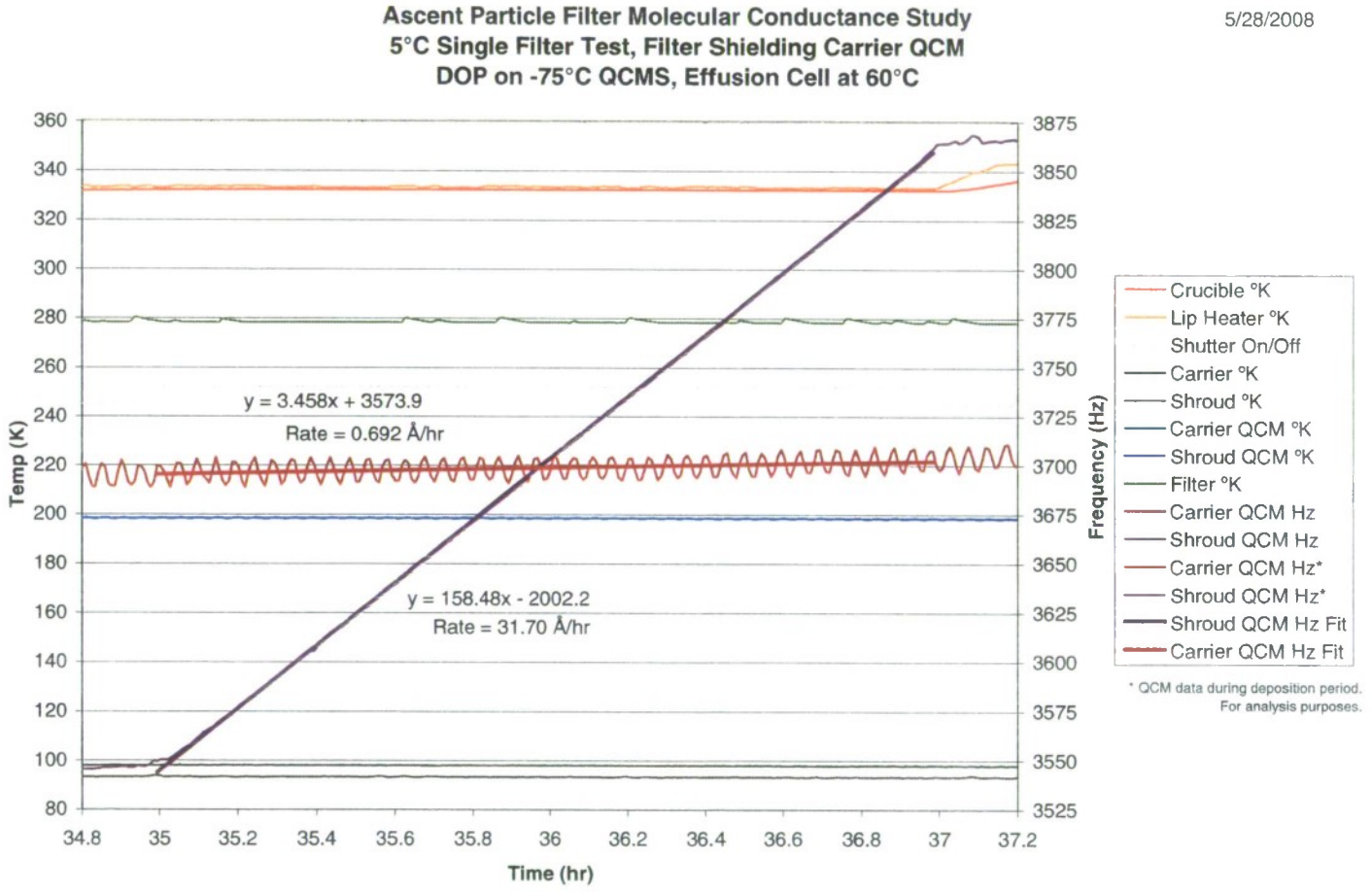

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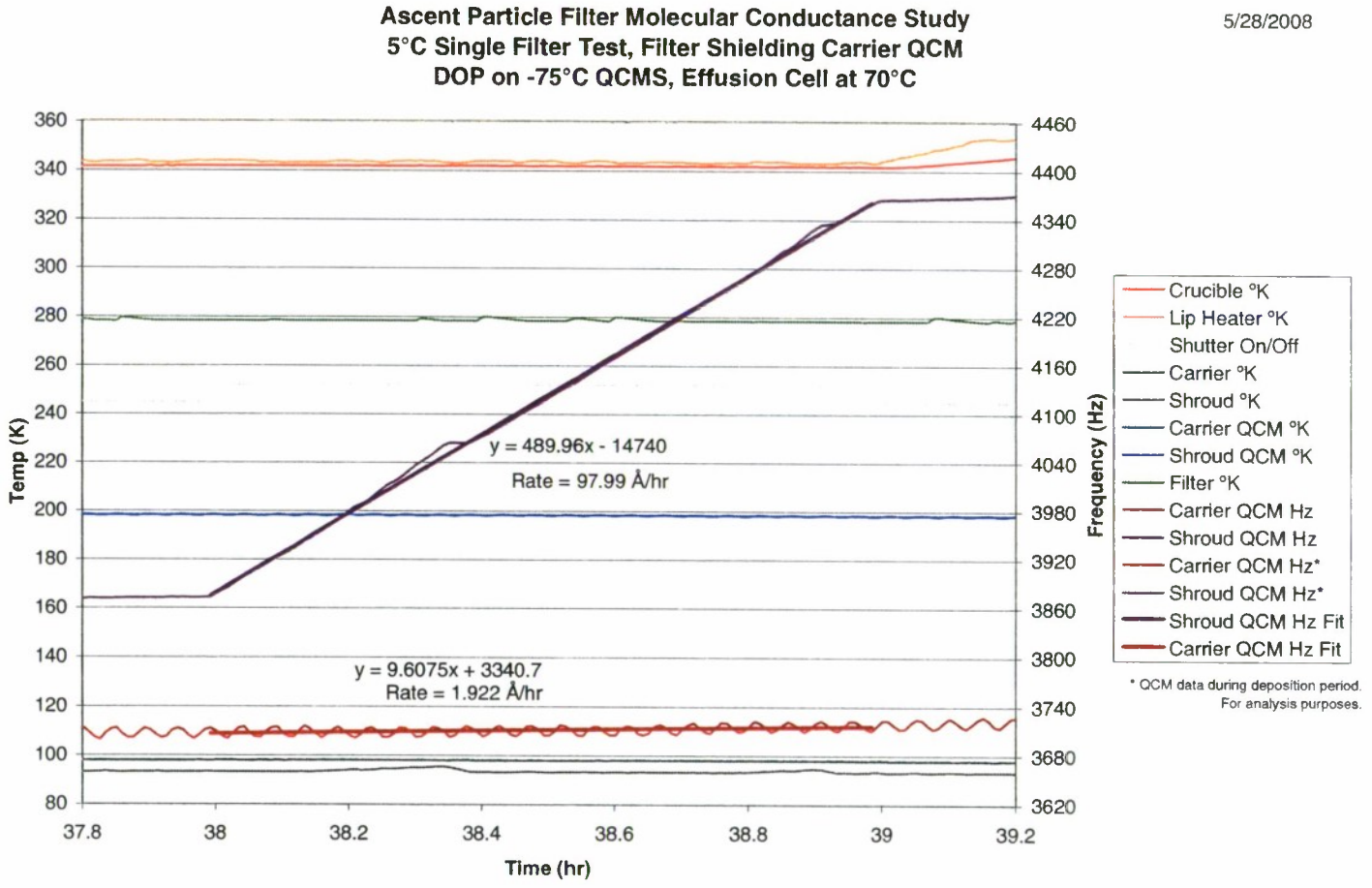

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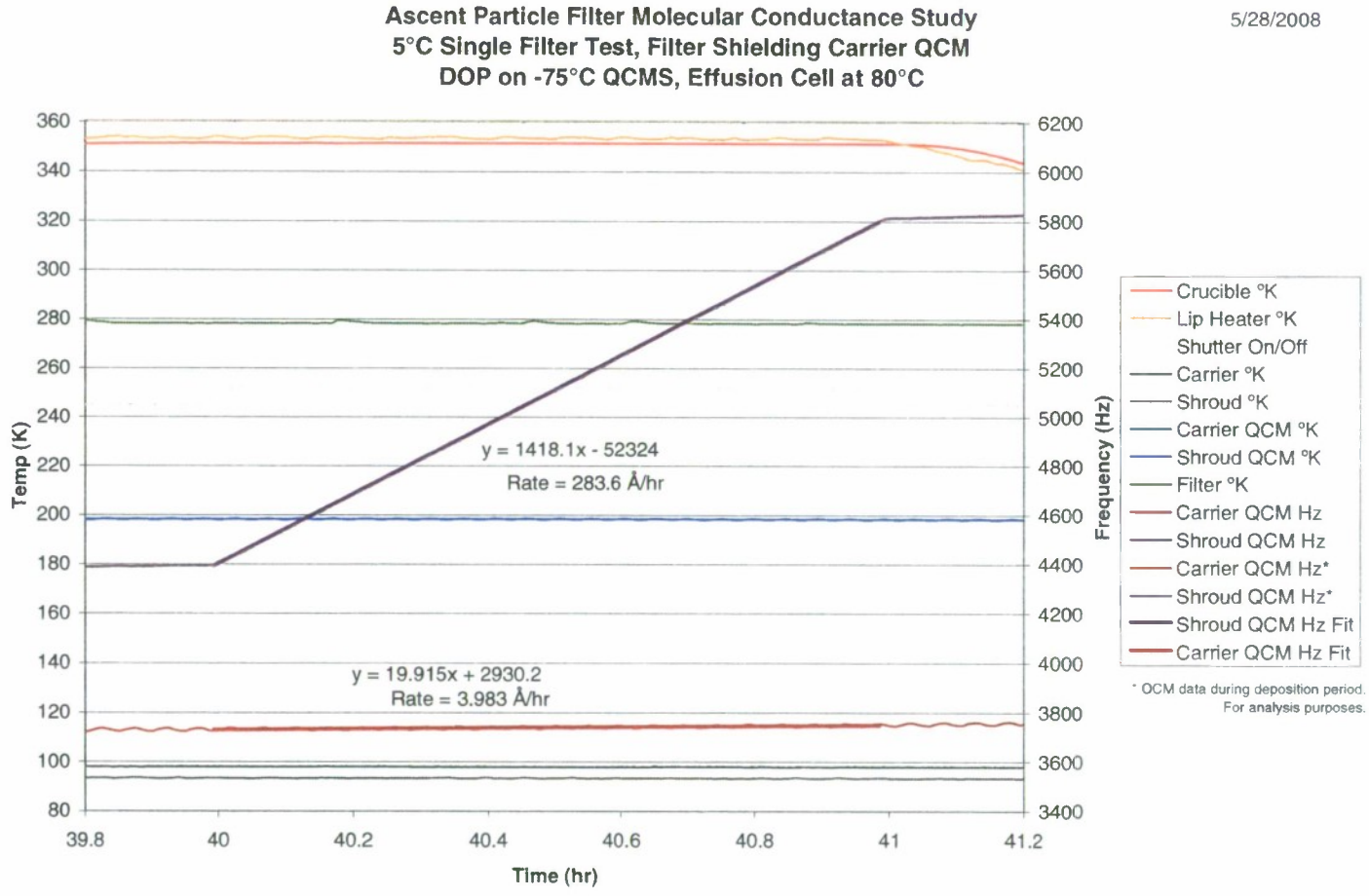

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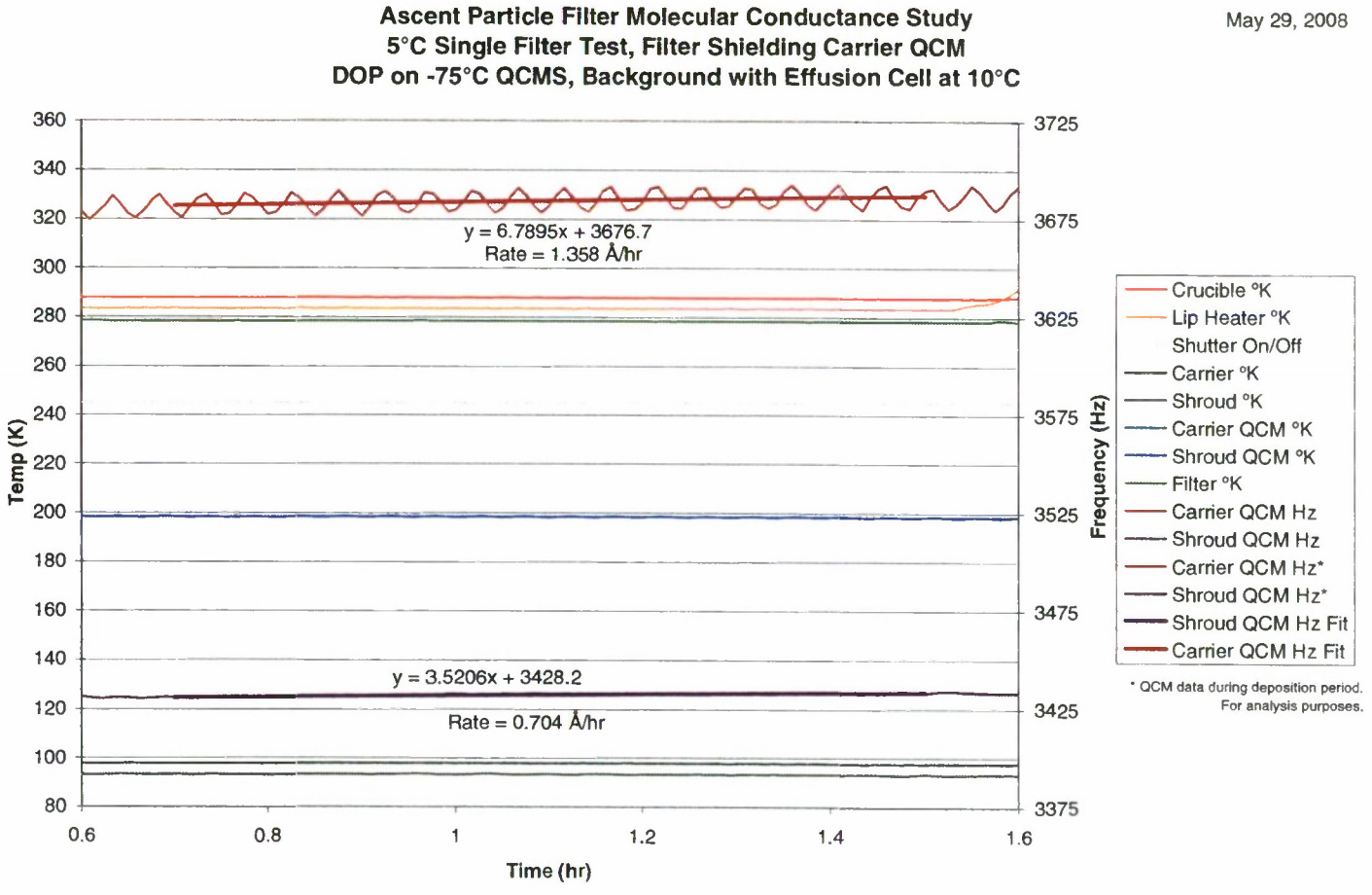

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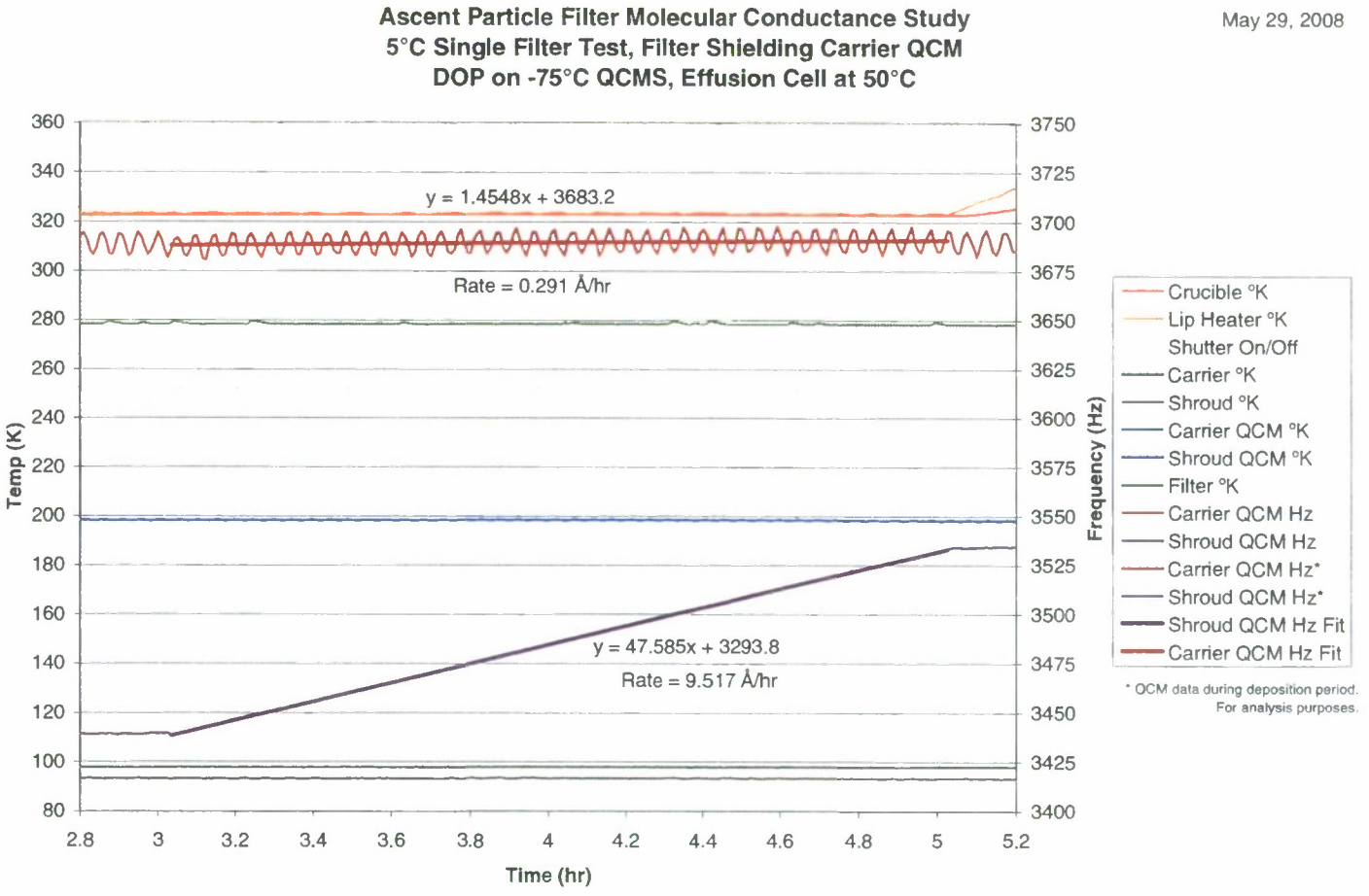

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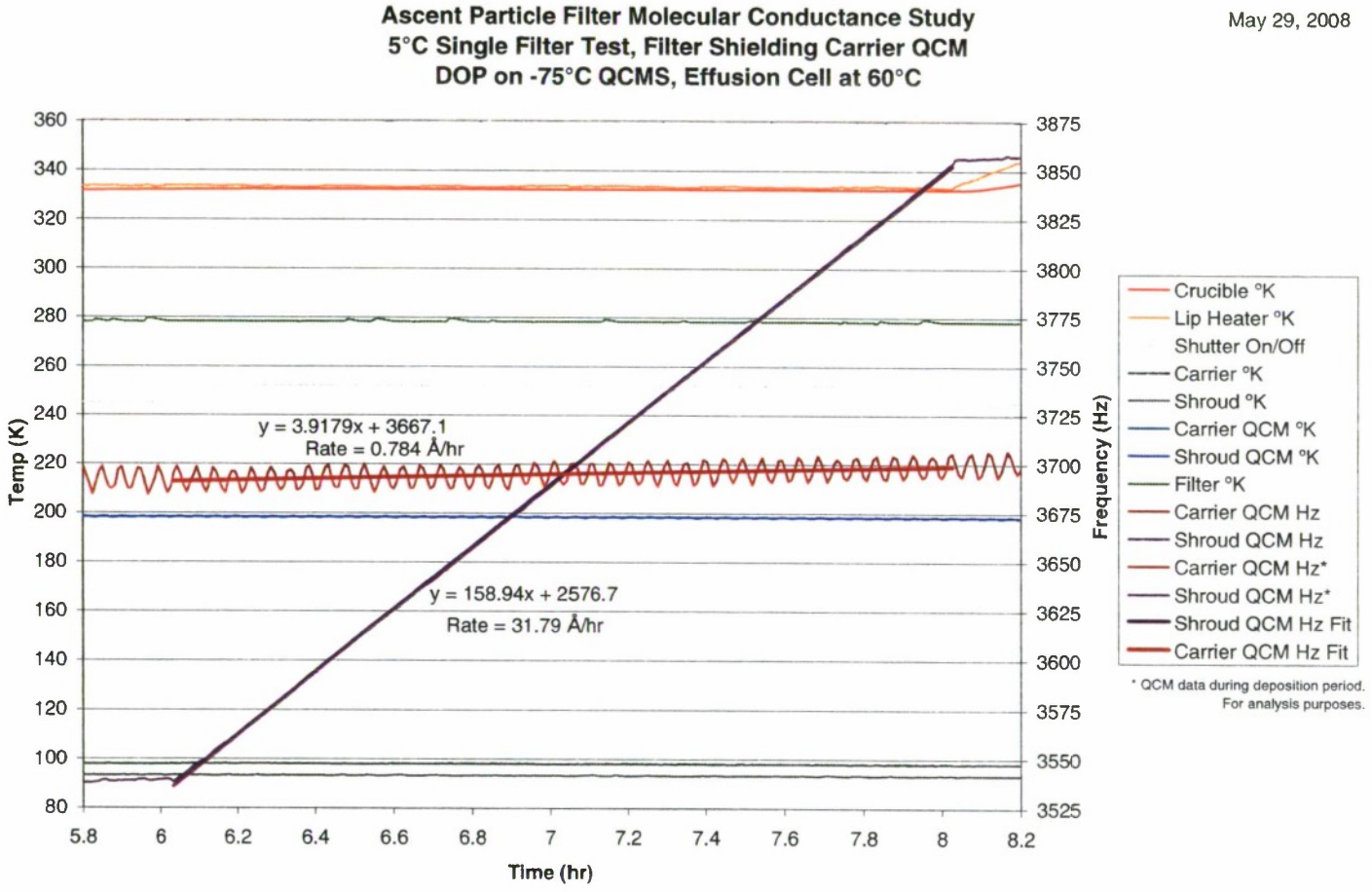

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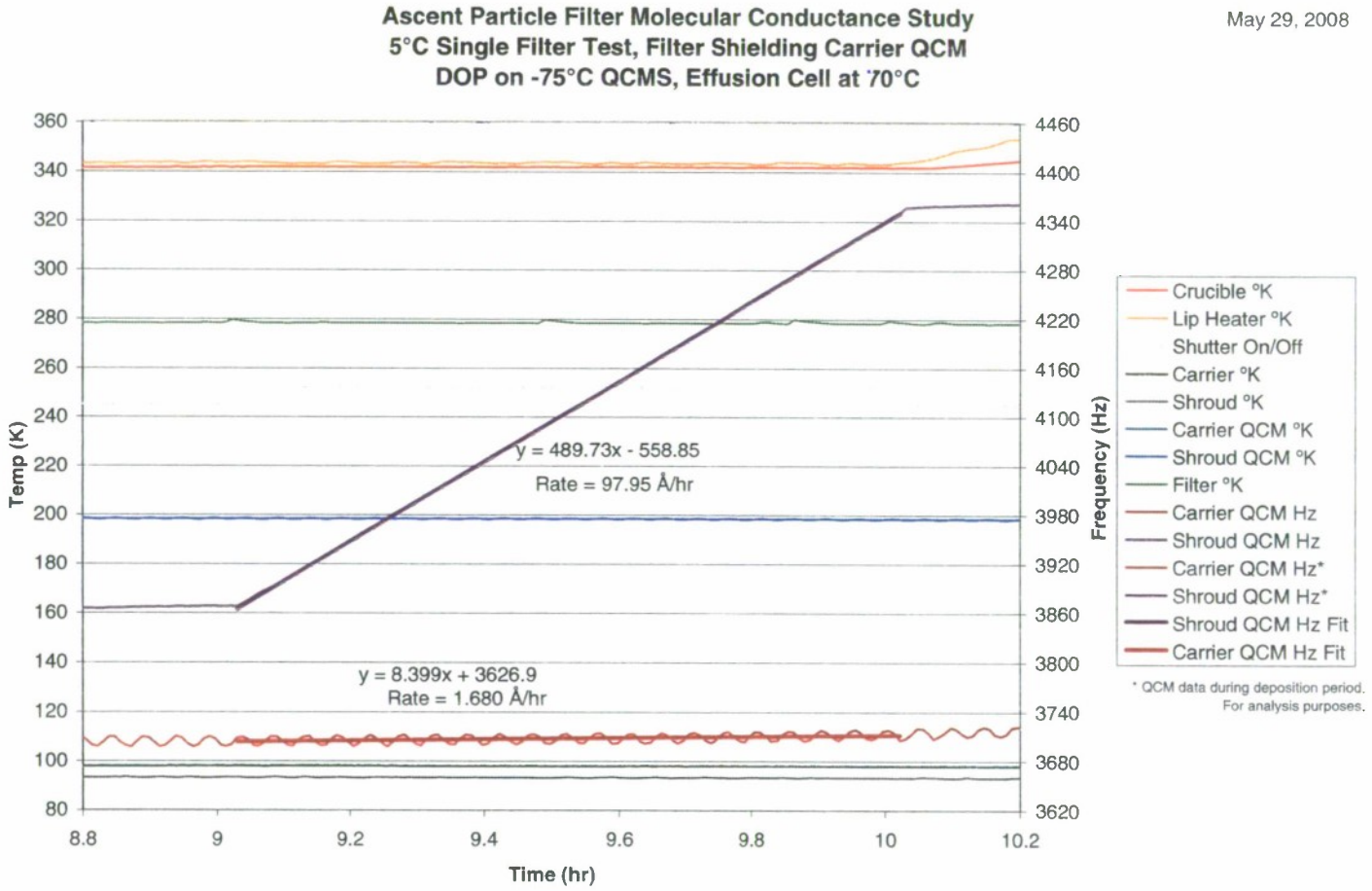

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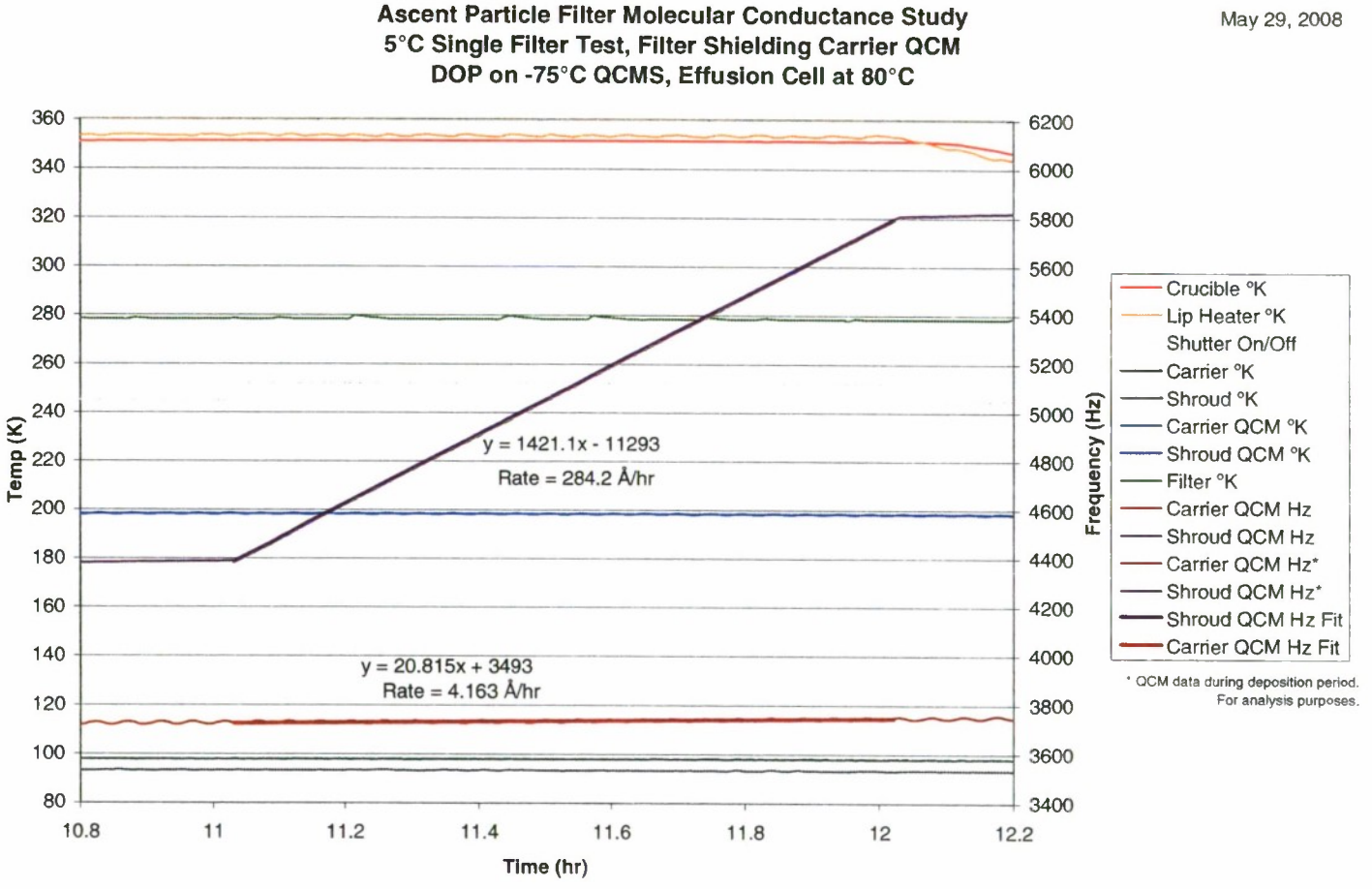

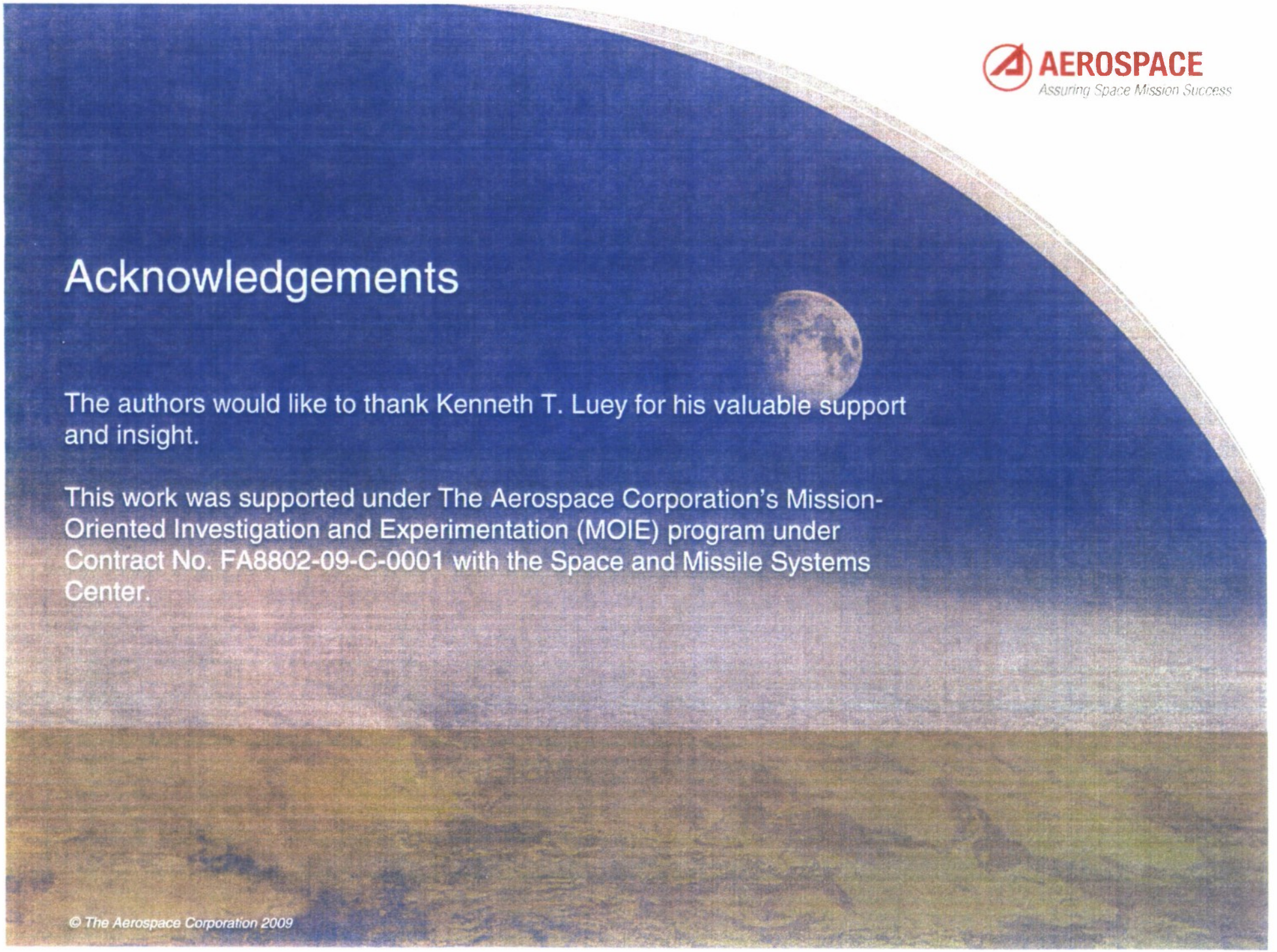

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El Segundo, California 90245-4609
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